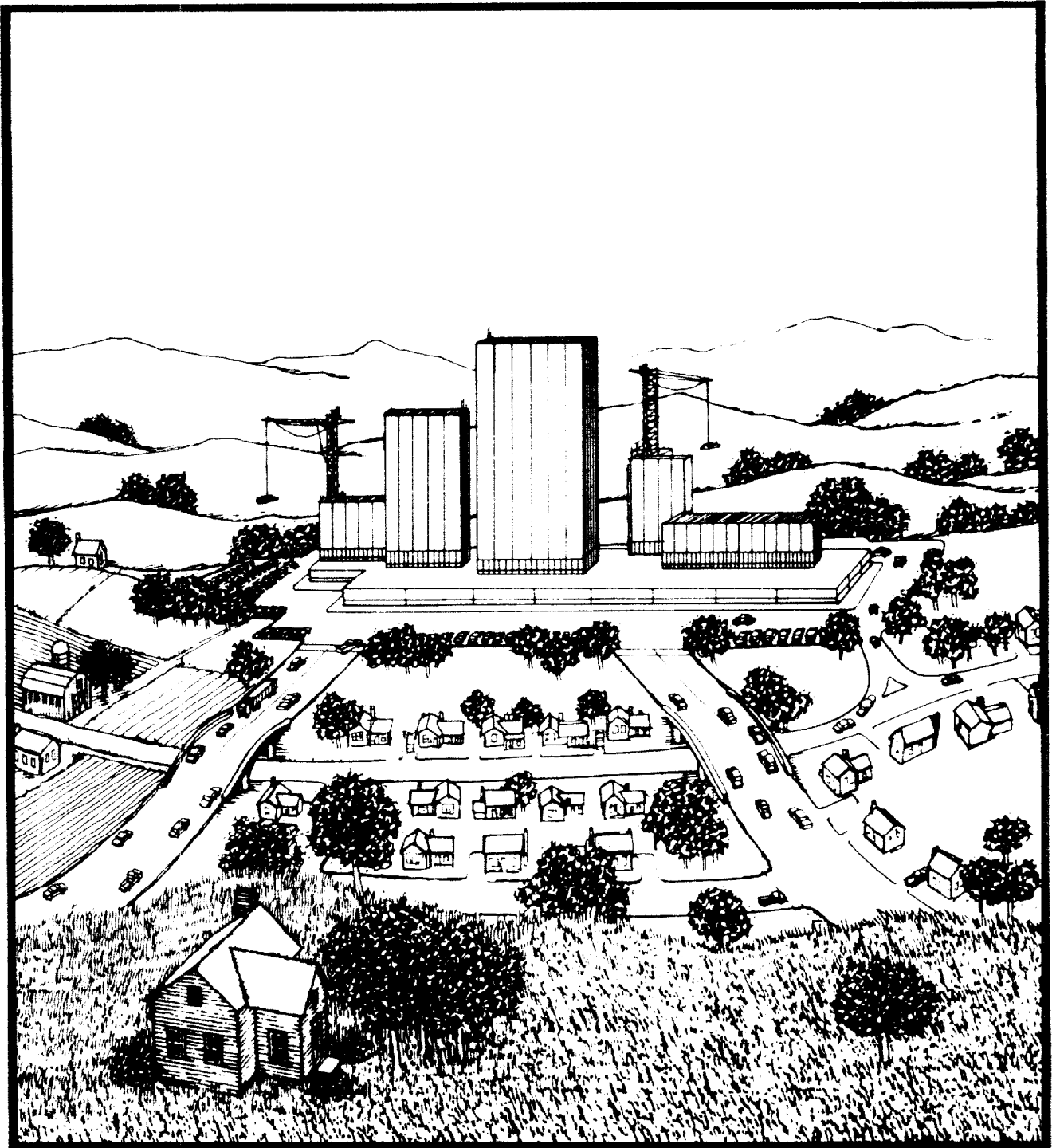




U.S. Department
of Transportation
**Federal Highway
Administration**

Site Impact Traffic Evaluation (S.I.T.E.) Handbook

Final Report
January 1985



612
770

NOTICE: This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

1. Report No. FHWA/PL/85/004	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Site Impact Traffic Evaluation (S.I.T.E.) Handbook		5. Report Date January 1985	
		6. Performing Organization Code	
7. Author(s) C. Richard Keller, Joe Mehra		8. Performing Organization Report No.	
9. Performing Organization Name and Address KELLERCO Two Tysons Corner Center McLean, Virginia 22102		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. DTFH61-83-C-00146	
12. Sponsoring Agency Name and Address U.S. Department of Transportation, Federal Highway Administration, Office of Highway Planning Institute of Transportation Engineers		13. Type of Report and Period Covered Final Report Sept. 1983 to Jan. 1985	
		14. Sponsoring Agency Code	
15. Supplementary Notes FHWA Contract Manager: L. A. Chimini			
16. Abstract <p>The study regarding the analysis and use of existing trip generation rates resulted in two reports:</p> <ul style="list-style-type: none"> * "Site Impact Traffic Evaluation (S.I.T.E.) Handbook" This report documents the site access study process in detail. As noted in the report, the trip generation estimation procedure is a critical step in the seven phase site access study. Four case studies are presented that demonstrate the use of trip generation rates and analyze the sensitivity of site related traffic to trip rates, trip distribution patterns and other key variables. * "Development and Application of Trip Generation Rates" This report presents an overview of the data sources on trip generation rates. Updated trip generation rates are presented along with factors for adjusting trip rates due to variations in residential characteristics. The use of trip rates is described. <p>While each of the two reports is an independent document, they complement each other, and the user would benefit from reading both reports.</p>			
17. Key Words Site Access, Traffic Impact, Trip Generation, Trip Distribution, Trip Assignment, Level of Service		18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 98	22. Price

1. Report No. FHWA/PL/85/004	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Site Impact Traffic Evaluation (S.I.T.E.) Handbook		5. Report Date January 1985	
		6. Performing Organization Code	
7. Author(s) C. Richard Keller, Joe Mehra		8. Performing Organization Report No.	
9. Performing Organization Name and Address KELLERCO Two Tysons Corner Center McLean, Virginia 22102		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. DTFH61-83-C-00146	
12. Sponsoring Agency Name and Address U.S. Department of Transportation, Federal Highway Administration, Office of Highway Planning Institute of Transportation Engineers		13. Type of Report and Period Covered Final Report Sept. 1983 to Jan. 1985	
		14. Sponsoring Agency Code	
15. Supplementary Notes FHWA Contract Manager: L. A. Chimini			
16. Abstract <p>The study regarding the analysis and use of existing trip generation rates resulted in two reports:</p> <ul style="list-style-type: none"> * "Site Impact Traffic Evaluation (S.I.T.E.) Handbook" This report documents the site access study process in detail. As noted in the report, the trip generation estimation procedure is a critical step in the seven phase site access study. Four case studies are presented that demonstrate the use of trip generation rates and analyze the sensitivity of site related traffic to trip rates, trip distribution patterns and other key variables. * "Development and Application of Trip Generation Rates" This report presents an overview of the data sources on trip generation rates. Updated trip generation rates are presented along with factors for adjusting trip rates due to variations in residential characteristics. The use of trip rates is described. <p>While each of the two reports is an independent document, they complement each other, and the user would benefit from reading both reports.</p>			
17. Key Words Site Access, Traffic Impact, Trip Generation, Trip Distribution, Trip Assignment, Level of Service		18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 98	22. Price

ACKNOWLEDGMENTS

Kellerco is most appreciative for the assistance rendered by U.S. Department of Transportation , the Institute of Transportation Engineers, and the staffs of several agencies throughout the country. U.S.D.O.T. staff who provided assistance included Ms. Louise Skinner, Mr. Leroy Chimini, Mr. Carl Shea, Mr. Christopher Fleet and Mr. George Schoener. Mr. Mark Norman of ITE provided valuable assistance. Dr. Everett Carter and Mr. Abdulla Meer acted as consultants to Kellerco. Mr. Sanjeev Malhotra provided research assistance on the study. Mr. Joe Mehra was the Principal Investigator and Mr. C. Richard Keller was the Principal-In-Charge.

TABLE OF CONTENTS

	Page No.
I. INTRODUCTION.....	1
BACKGROUND.....	1
ORGANIZATION OF REPORT.....	3
II. OVERVIEW OF SITE ACCESS STUDY PROCESS.....	5
III. SITE ACCESS STUDY PROCESS.....	11
PHASE I. ESTABLISH STUDY DESIGN AND VERIFY EXISTING PEAK HOUR TRAFFIC.....	11
PHASE II. PROJECT FUTURE PEAK HOUR TRAFFIC SITUATION WITHOUT SITE DEVELOPED.....	20
PHASE III. PROJECT PEAK HOUR SITE DEVELOPMENT TRAFFIC.....	23
PHASE IV. PROJECT FUTURE PEAK HOUR TRAFFIC SITUATION WITH SITE DEVELOPED.....	24
PHASE V. DEVELOP SITE ACCESS RELATED SOLUTIONS.....	27
PHASE VI. NEGOTIATE SITE ACCESS.....	29
PHASE VII. IMPLEMENT PROJECT/ACCESS IMPROVEMENTS.....	30
IV. CONCLUSIONS.....	33
SUMMARY OF CASE STUDIES.....	34
APPENDICES	
A DEFINITIONS: SITE ACCESS STUDY TERMINOLOGY	
B ISSUES AND TRENDS IN SITE ACCESS STUDIES	
C TECHNICAL BACKGROUND	
D CASE STUDIES	

LIST OF FIGURES

<u>Number</u>		<u>Page</u>
1	Flowchart of Site Access Study Process.....	6
2	Summary of Basic Site Access Study Process.....	8
3	Frequency of Complex Issues Occurring In Typical Site Access Studies.....	10
4	Typical Parameters For A Basic Site Access Study.....	13
4a	Typical Parameters For A Complex Stage I (+5 Years) Site Access Study For A Proposed Mall.....	15
4b	Typical Parameters For A Complex Stage II (+10 Years) Site Access Study For A Proposed Mall.....	16
4c	Typical Parameters For A Complex Stage III (+20 Years) Site Access Study For A Proposed Mall.....	17
5	AM Peak Hour Level Of Service Comparison For Intersection 1.....	26

Appendices

C-1	Example Of Geographic Distribution Of Office Building Generated Trips During AM Peak Hour.....	C-7
C-2	Example Of Geographic Distribution Of Site Generated Traffic, As A Percent of Total Inbound Trips Generated For Short, Mid Term and Long Term Road Networks.....	C-8
D-1	Case Study No.1 Site Location And Road Network.....	D-3
D-2	Case Study No.1 "A" Trip Distribution For Office and Motel Generated Trips (Existing Situation And Conditions 1, 2, & 4).....	D-8
D-3	Case Study No.1 "B" Trip Distribution For Office And Motel Generated Trips (Condition 3).....	D-9
D-4	Case Study No.2 Site Location With Respect To Road Network.....	D-13

LIST OF FIGURES (Continued)

<u>Number</u>		<u>Page</u>
D-5	Case Study No.2 Geographic Distribution Of Site Location.....	D-14
D-6	Location Of Case Study No.3 Site With Respect To Area Road Network.....	D-21
D-7	Case Study No.3 New Development Anticipated By 1987	D-23
D-8	Case Study No.3 General Geographic Distribution.....	D-25
D-9	Case Study No.3 1987 Road Network.....	D-26
D-10	Case Study No.4 Site Location And Road Network.....	D-31

LIST OF TABLES

<u>Number</u>	<u>Page</u>
B-1	Market Shifts In The 80's..... B-4
C-1	Example Of Technique For Estimating Office Building Peak Hour Generated Trips..... C-3
D-1	Case Study No.1 Alternative Conditions Evaluated... D-7
D-2	Case Study No.1 Peak Hour Level Of Service Comparison 1 For Conditions 1,2,3,4..... D-11
D-3a	Case Study No.2 AM/PM Peak Hour Trip Generation Rates By Land Use For Alternative Conditions..... D-15
D-3b	Case Study No.2 AM/PM Peak Hour Comparison of Traffic Generated For Alternative Condition..... D-16
D-4	Case Study No.2 Condition 5 Internal/External Traffic..... D-18
D-5	Case Study No.2 Peak Hour Level of Service Comparison for Condition 1 thru 5..... D-19
D-6	Case Study No.3 Site Generated AM/PM Peak Hour Volumes..... D-24
D-7	Case Study No.3 Peak Hour Level of Service Comparison for Conditions 1 thru 4..... D-28
D-8	Case Study No.4 Base Condition A..... D-33
D-9	Case Study No.4 Condition B..... D-34
D-10	Case Study No.4 Condition C..... D-35
D-11	Case Study No.4 Condition D..... D-36
D-12	Case Study No.4 Condition E..... D-37
D-13	Case Study No.4 Condition F..... D-38

LIST OF TABLES (Continued)

<u>Number</u>		<u>Page</u>
D-14	Case Study No.4 Condition G.....	D-39
D-15	Case Study No. 4 Peak Hour Level of Service Comparison For Condition A Thru G.....	D-41

I. INTRODUCTION

A "site access study" is a generic term commonly used by transportation/land use planners and traffic engineers to describe how traffic generated by either new land use(s) or replacement land use(s) will be served by an existing or future road network. [1]

Since the technical analyses allow for the effect of site generated traffic on the road network, the term "traffic impact" has been frequently applied to this study process. While "traffic impact" may be of interest, it is not the only reason for such studies, and therefore the term "site access study" is considered more appropriate.

BACKGROUND

A site access study involves technical analyses applied to a distinct study area which may range from one or two key intersections to a complete roadway network encompassing numerous intersections and interchanges; and occasionally extending a mile, or several miles, from the specific site. Since the study is usually related to land use regulations, the principal reviewing agency is usually a city, town, township, or county. A regional agency such as an MPO (Metropolitan Planning Organization) will have an assisting or coordinating role in most cases. State agencies usually review the findings to satisfy responsibilities for major public facilities, i.e. State or Federal roadways, water, utilities, environmental impact, etc. The regional agency is often used as a data resource insofar as travel demand and land use projections are concerned. Since a site access study is usually performed at a local or subarea level, areawide data are not directly applicable to the type of analyses needed to perform a site access study. It is becoming increasingly important for the regional agency to maintain a record of the roadway improvements implemented as a result of site access studies. Significant changes are sometimes made in the regional road network, which may influence regional travel analyses.

Since the site access study process is being used more and more as a basis for establishing a developer's share of future roadway improvements, the technical analyses are increasingly being used for negotiations between public and private groups (See Appendix B for a discussion of the issues and trends related to site access studies). This places great importance on certain elements of the technical analyses, such as trip

[1]. See Appendix A for definitions of site access terminology

generation rates, trip distribution patterns, mode split analyses and the percentage of site trips arriving or departing during the peak hour. The emphasis on privately financed improvements or contributions has also led to the extension of the study area boundaries to ensure that the widest range of public concerns are included. In any event, site development projects contribute very significant roadway improvements to the benefit of both the development and the public. Of course, the extent of the improvement varies by size of the project. In addition, financial contributions are frequently made to a general "subarea" roadway improvement fund on the basis of the density (trips generated) of the proposed development. The public-private negotiation process primarily involves commercial-retail development. Financial aspects of residential development apparently preclude significant financial roadway commitments beyond site related roads.

A site access study may be performed for a basic condition or a very complex condition. For example, a basic condition would refer to a small retail store or day care center to be built on a one acre tract and occupied within one year. A complex condition would refer to a major development such as a 100-acre tract with 3 to 4 million square feet of mixed use development consisting of hotels, office buildings, a retail mall and residential units. Full occupancy may not occur for 10 to 15 years. The same basic technical analyses apply to both conditions. The 100-acre tract involves more complex issues and therefore involves more detailed technical analyses and the need for professional experience.

The technical analyses which constitute a site access study are usually performed by either a transportation planner or traffic engineer, acting as a consultant, with the study cost being paid by the developer of the subject tract. Occasionally, the studies are performed by consultants for public agencies such as a town, city, or county either in lieu of a developer's study or as an independent study for comparison to a developer's study if sufficient agency staff are not available. Sometimes the developer will be required to reimburse the public agency for the site access study.

This report was prepared to promote a better understanding of the site access study process. While such studies have been conducted throughout the U.S. for many years, there is very little technical documentation of the basic study process or general guidelines. This has probably occurred because the studies are usually performed to satisfy local zoning (where applicable), ordinances or land use regulations; and their technical content varies to the extent necessary to resolve

conflicting issues. Due to the variation in state and local land use regulations, the information contained in this report should be considered as a general guideline only. The technical analyses and procedures described should be altered to satisfy specific regulations as applicable to: 1) a specific site development plan and 2) local and state land use regulations.

ORGANIZATION OF REPORT

This report describes the basic site access study process, and the technical implications which tend to create a complex site access study. The remainder of the report is organized as follows:

- Chapter II presents an overview of the site access study process. The seven phases of the process are cross referenced in Chapter III.
- Chapter III describes the seven phases of the basic site access study process. Variations for a complex study are also discussed.
- Chapter IV presents the conclusions and a summary of the four case studies described in Appendix D.
- Appendix A presents definitions of the terminology used in site access studies.
- Appendix B discusses the issues and trends related to site access studies.
- Appendix C presents a description of the trip generation, trip distribution/assignment and level of service procedures used in a site access study.
- Appendix D presents four case studies which illustrate the use of trip generation rates and the sensitivity of trip generation rates with respect to certain elements of the site access study process.

[This page intentionally left blank]

II. OVERVIEW OF SITE ACCESS STUDY PROCESS

The site access study process is depicted in the flowchart in Figure 1. Each of the seven phases of a basic study are summarized in more detail in Figure 2.

Phase I establishes the study design based on discussions and agreements with local officials. Data collection and/or analyses then result in the verification of the existing background traffic situation and peak hour levels of service.

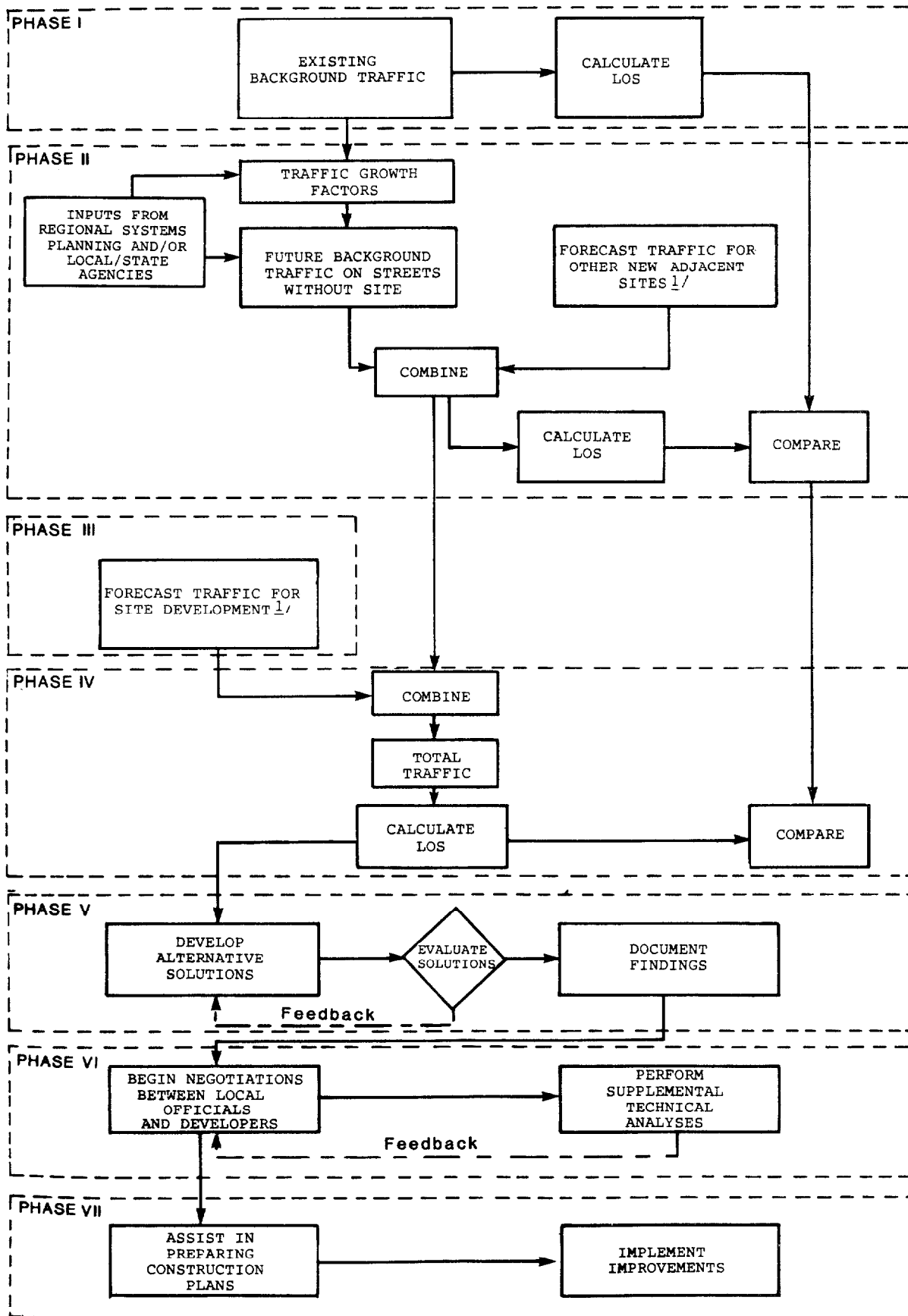
Phase II uses Phase I existing background traffic and inputs from regional systems planning and/or local/state agencies to estimate future background traffic without the site developed. The traffic generated by other new developments adjacent to the site are forecast using trip generation, distribution and assignment procedures as described in Appendix C. The levels of service without the site developed can be estimated by combining future background traffic and traffic for new adjacent sites.

Phase III deals exclusively with site specific generated traffic, organizing the data in a format so it can be combined with Phase II data. This phase is similar to the forecasting of traffic for the other new adjacent sites performed in Phase II.

Phase IV establishes the peak hour situation with the site fully developed and occupied. The Phase IV total traffic is estimated by combining the results of Phase II and Phase III. The Levels of Service (LOS) with the site traffic are then estimated. A comparison of the LOS between Phase II and Phase IV results shows the impacts of the site traffic. The comparison of Phase II (without the site developed) to Phase IV (with the site developed) is not always sufficient. With the site developed may mean "as-zoned" or "as-proposed" leaving two options to be studied rather than one. Whether or not this strategy is pursued is an administrative decision often based on negotiations.

Phase V is a creative process which identifies and analyzes alternative site access related improvements. While this phase usually involves a roadway or traffic operational improvement (such as changes to signal phasing or the addition of turn lanes), it may also include major roadway improvements or Transportation Systems Management (TSM) actions to limit or reduce peak hour traffic. The alternative solutions are evaluated for peak hour effectiveness. The study findings (Phases I through V) are then documented for review by the local officials.

FIGURE 1
FLOWCHART OF SITE ACCESS STUDY PROCESS



^{1/} See Appendix C for technical procedures

The negotiations between local officials and the developers are carried out in Phase VI. During negotiations with local officials, the solution may change significantly, requiring additional analyses. Further issues may be raised which were not addressed in the original analysis, regarding TSM actions for reducing peak hour traffic, or developer sponsored ridesharing programs or shuttle bus/van service. This can lead to more detailed analyses, modification of the original LOS results, and a change in site access related improvements. Supplemental technical analysis may be needed to resolve outstanding issues with citizen groups who are interested in average daily traffic. The peak hour based analyses can then be modified to represent the change in 24 hour "daily" volumes on key road links without and with the site developed.

Phase VII is the implementation phase, which occurs after agreement is reached between the developers and the local officials. Authorization by the local officials is usually in the form of a permit to construct the improvements or to provide funds for all or a share of the improvements. TSM actions such as ridesharing or shuttle bus service may also be provided by the developer. Final site plans and road construction plans are then provided by the site engineer and architect. Parking facility (lots, garage, decks), circulation and entrance details are particularly important. If the developer is responsible for the signalization of an intersection(s), installation plans and specifications are developed for review by state and local officials.

The basic site access process can change significantly for a complex site access study. This not only increases the study cost, but also extends the study time frame. The technical issues associated with a complex study are discussed for each appropriate phase in the next Chapter. These issues are summarized in Figure 3 along with the probability of the issue being raised in a typical re-zoning case for three typical land use options. The frequency of occurrence depends on a variety of site specific issues other than size. Also noted by a (+) are the items considered to be on an increasing trend. This is possibly due to an increased awareness and knowledge of attributes of the technical process, on the part of local officials, developers, transportation planners or traffic engineers. Large tracts have always been more complex to study, but two recent trends have placed more emphasis on such studies:

- * the more accessible large tracts have been developed, leaving the more difficult large tracts to be developed;
- * the financial or economic situation may influence the tendency to develop larger tracts more intensely than in the past.

FIGURE 2
SUMMARY OF BASIC SITE ACCESS STUDY PROCESS

<u>Topic</u>	<u>Page No.</u>
PHASE I. ESTABLISH STUDY DESIGN AND VERIFY EXISTING PEAK HOUR TRAFFIC	
* Confirm Site Development Program	11
* Meet with Local Officials to Establish Study Area and Parameters	12
* Establish Study Design Parameters	12
* Evaluate Data Needs	18
* Collect New Data (Optional)	19
* Tabulate Data; Calculate LOS [1]	19
* Identify Site Access/Circulation Constraints and Opportunities	20
PHASE II. PROJECT FUTURE PEAK HOUR TRAFFIC SITUATION <u>WITHOUT</u> SITE DEVELOPED	
* Establish Past Growth Rate in Key Corridor(s)	20
* Identify Changes in Road Network and Land Use Type/Density	21
* Project Phase I Peak Hour Traffic to Future Study Year ...	22
* Calculate Level of Service	22
* Identify Changes between Existing and Future Situation ...	23
PHASE III. PROJECT PEAK HOUR SITE DEVELOPMENT TRAFFIC	
* Select and Apply Appropriate Trip Generation Rates	23
* Determine Trip Distribution Pattern and Assign Trips to Road Network	24
PHASE IV. PROJECT FUTURE PEAK HOUR TRAFFIC SITUATION WITH SITE DEVELOPED	
* Combine Phase II Background Traffic with Phase III Assigned Traffic to Achieve Total Peak Hour Traffic	24
* Calculate LOS; and Compare to Phase I and Phase II LOS Results	24
* Identify Changes between Phase I, Phase II and Phase IV Results	25

[1] LOS - Level Of Service; as related to the level of intersection operating efficiency

FIGURE 2 (continued)
SUMMARY OF BASIC SITE ACCESS STUDY PROCESS

<u>Topic</u>	<u>Page No.</u>
PHASE V. DEVELOP SITE ACCESS RELATED SOLUTIONS	
* Evaluate Alternative Solutions to Achieve Acceptable Levels Of Service	27
* Select Preferred Solution; Document Findings	28
PHASE VI. NEGOTIATE SITE ACCESS	
* Begin Negotiations between Local Officials and Developers to Reach Agreement on the Proposed Development	29
* Perform Supplemental Technical Analyses to Resolve Outstanding Issues	29
PHASE VII. IMPLEMENT PROJECT/ACCESS IMPROVEMENTS	
* Assist Site Engineer in Preparing Construction Plans	30
* Develop Signalization Plans/Specifications (If Applicable) for Bid	30
* Privately Funded Roadway or Traffic Operational Improvements Implemented	31

FIGURE 3
FREQUENCY OF COMPLEX ISSUES OCCURRING
IN TYPICAL SITE ACCESS STUDIES

<u>ISSUES</u>	One Acre Free Standing <u>Store</u>	40 Acre <u>Retail Mall</u>	110 Acre Mixed Use Office-Hotel <u>Mall Complex</u>
PHASE I			
+ 10 to 15 year build-out requires interim stage analyses	seldom	seldom	frequently
+ Special survey needs	seldom	occasionally	frequently
PHASE II			
* Significant changes in road network	seldom	occasionally	frequently
+ Significant new land use near subject site	seldom	occasionally	occasionally
+ Major site related improvements require 20 year analysis	never	seldom	usually
PHASE III			
+ Physical site characteristics restrain site access	seldom	seldom	occasionally
* Hybrid land use option requires trip generation research	occasionally	seldom	occasionally
* Expansion of retail mall requires trip linking research	NA	occasionally	seldom
PHASE IV			
+ As-zoned vs. proposed analyses required	occasionally	occasionally	frequently
PHASE V			
+ LOS comparison requires careful solution development	seldom	occasionally	usually
PHASE IV			
+ TSM actions require further analysis	seldom	seldom	occasionally
* ADT traffic analyses required	occasionally	occasionally	occasionally
PHASE VII			
+ Developer implements access improvements	seldom	frequently	frequently

"+" indicates items which appear to be on an increasing trend

III. SITE ACCESS STUDY PROCESS

This chapter discusses each of the seven phases of the site access study process. The discussion follows the general outline presented in Figure 1. The technical guidelines associated with each of the seven phases of a basic site access study are described in this chapter. Variations for a complex site access study are noted where applicable.

PHASE I. ESTABLISH STUDY DESIGN AND VERIFY EXISTING PEAK HOUR TRAFFIC

Phase I of the site access study process results in the establishment of a study design based on discussions and agreements with the local officials. Further, the data collection efforts are carried out in this phase resulting in the verification of the existing peak hour traffic situation in the defined study area. The various steps in Phase I of the site access study process are described below.

* Confirm Site Development Program

Perform a field reconnaissance of the site during peak traffic conditions. Meet to discuss with the developer and other members of the project team the following site related items: [2]

- proposed land use type/density including staging
- current zoning classification and allowable land use/density
- year project will be fully developed/occupied
- basic site access constraints/opportunities (e.g. easements, right-of-way, etc.)
- available site plans
- development program strategy/schedule
- on site circulation, ingress/egress points, building locations, parking lots, garages/decks (to the extent information is available)
- complex studies will require discussion of long term implications and may need 10-, 15-, and/or 20-year analyses because of the length of the buildout period.

[2]. "Project Team members" vary depending on the purpose of a study. They may include: attorney; architect; site engineer; landscape architect; transportation planner; traffic engineer; site planner; and/or developer.

* Meet With Local Officials To Establish Study Area And Parameters

Typical parameters include:

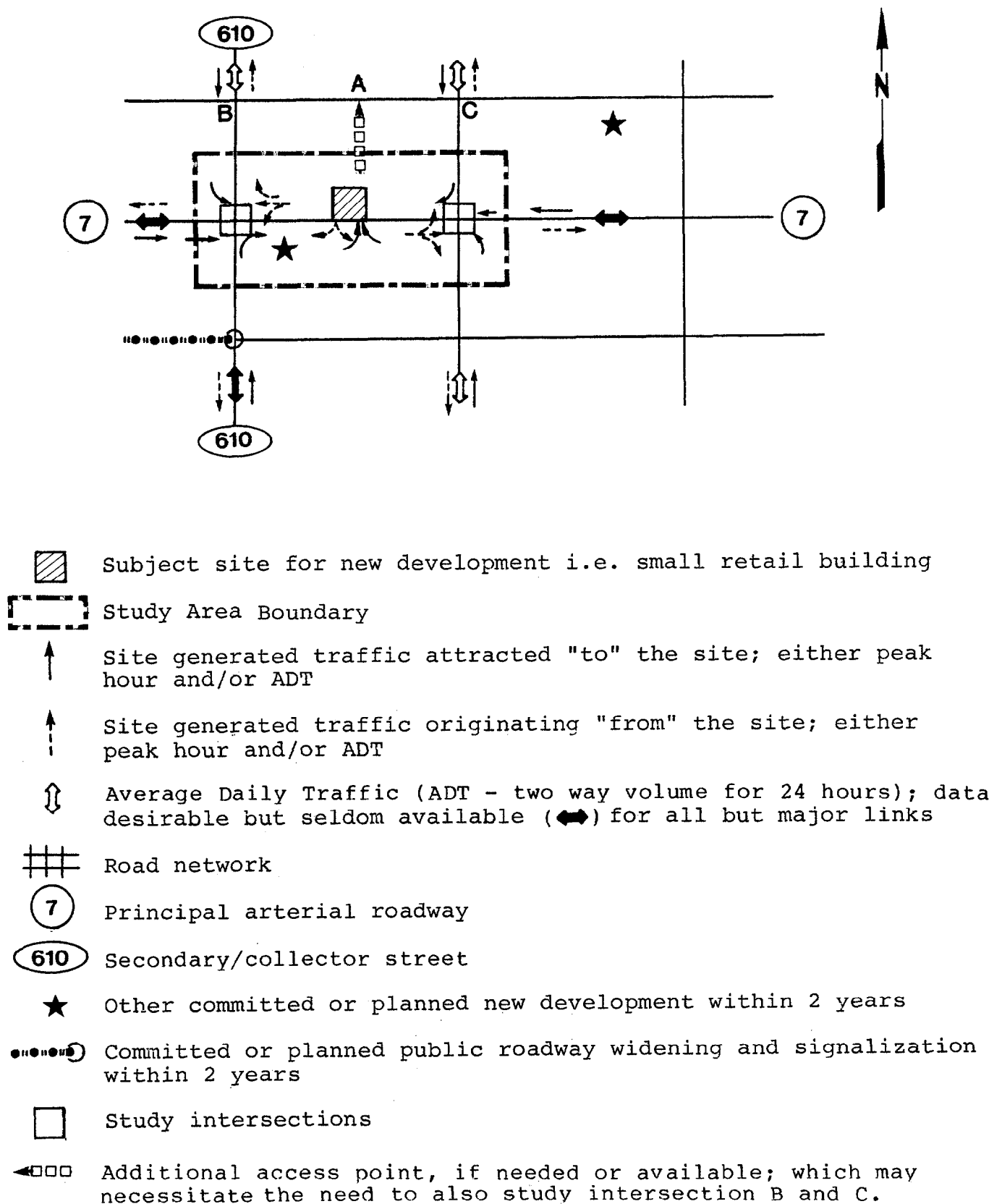
- planned and committed road/traffic operational improvements; land use developments (type, density and location); and site implications
- subject site relationship to adjacent land uses/roadways
- study area boundary definition; key intersections and special traffic operational issues
- applicable peak hour turning movement counts and 24 hour traffic volumes for 3 to 5 year period
- applicable public facilities design standards
- traffic signal turning/phasing for key signalized intersections to include interconnection
- applicable roadway construction plans for geometrics and right-of-way
- applicable comprehensive plan elements
- technical procedures for calculating Level of Service
- access/circulation issues of particular concern, including possible citizen issues
- special data needs for unusual land uses or access problems.

* Establish Study Design Parameters

This is probably the most critical task after discussions with both the developer and local officials have taken place. Interpretation of the most potentially relevant issues requires considerable experience for larger tracts; and occasionally for small tracts due to unusual circumstances. This task should encompass both a graphic critique and workshop type discussion of key issues, with the technical analyses designed to resolve critical issues. Figure 4 illustrates typical parameters of concern for a basic study accomplished within six months.

First consider the study area boundary, and include sufficient area to ensure that technical issues will most likely be resolved. As illustrated, a basic study may only encompass two intersections and a site entrance. At each intersection, items such as lane configuration, geometrics, signal timing and phasing, and peak hour queues should be considered as applicable. Changes in the road network over buildout time frames are particularly important because the nature and extent of site access may change significantly. Key road corridors should be selected and potential (other) land use developments noted by location and density.

FIGURE 4
TYPICAL PARAMETERS FOR A BASIC SITE ACCESS STUDY



The effect of one way roads should be considered by evaluating inbound (to the site) and outbound (from the site) access routes for site generated peak hour trips. For example, inbound site access routes may not be the reverse of outbound routes due to the road network configuration. As illustrated in Figure 4, if the site had a second access route to point A, two additional intersections, B and C, might have been selected if the tract generated significant traffic at all four intersections.

Historical 24 hour ADT data needs (obtained from the state highway departments or local agencies) would be considered along with citizen issues associated with ADT projections. Unusual site related facilities such as toll roads, pending development projects with planned road improvements, new subway or rail facilities, new bus service etc. should be considered with respect to their effect on site access, on both a short and long term basis.

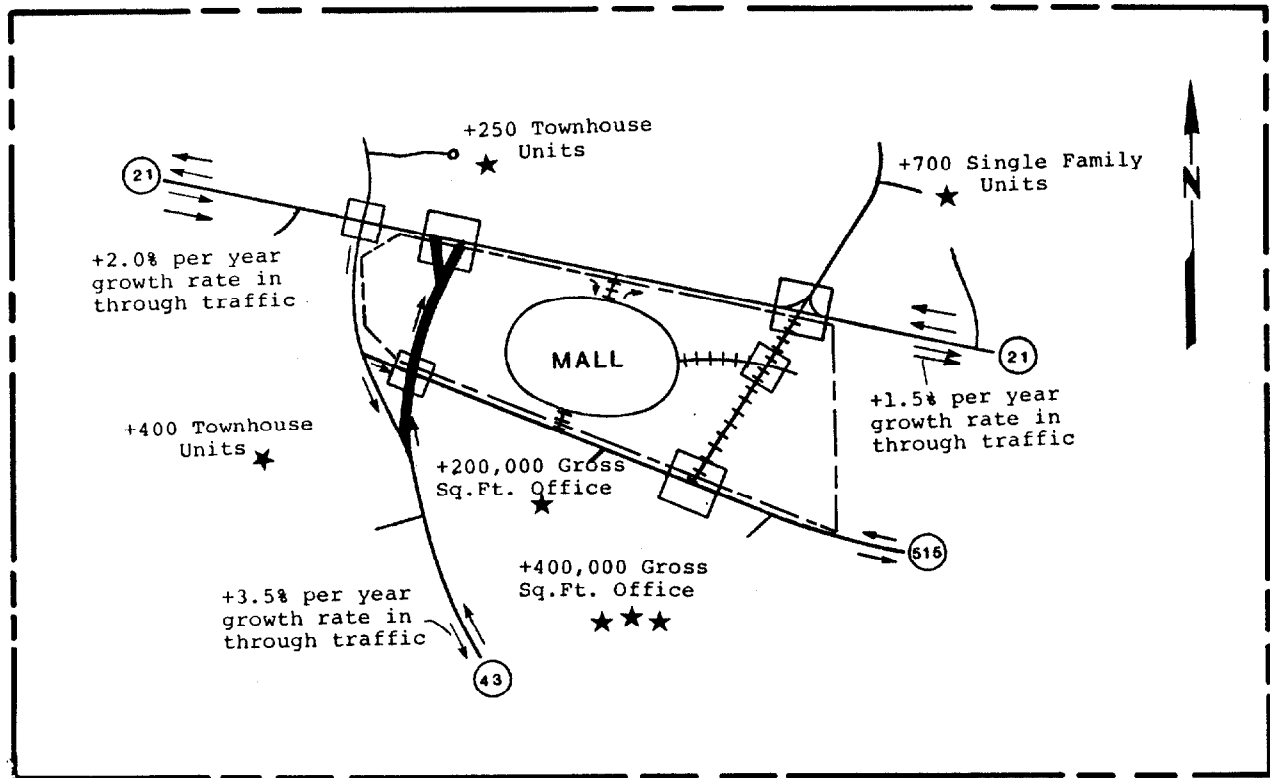
Since a complex site access study encompasses a larger study area and a larger more complex development, it will involve more road links and new area land developments. Figures 4a, 4b and 4c were prepared to compare the basic study in Figure 4 to a more complex three stage site access study featuring +5, +10 and +20 year conditions for a new mall project.

Figure 4a shows a mall development with a +5 year road network which is achieved by considering the existing roadways plus planned/ committed public improvements plus site related improvements. Naturally if the short term peak hour situation is being studied without the subject site being developed, site related roadway improvements would be deleted from this road network. Figure 4a also shows additional (committed and planned) development anticipated near the site during the short term period. Peak hour traffic for this additional development should be generated, distributed and assigned to the road network. Besides the site and additional development trips, corridor traffic would be increased (by the growth rates indicated) to account for new development beyond the study area. The resultant corridor volumes can then be compared to areawide traffic projections, if they are available. Usually this modeling process presents a realistic view of the most probable short term situation for detailed peak hour analyses.

Figure 4b shows Stage II of the subject site development during the +5 to +10 year period. Again the road network changes with various road improvements, and additional new study area development is identified.

Figure 4c shows the +20 year regional situation with additional

FIGURE 4a
TYPICAL PARAMETERS FOR A COMPLEX STAGE I (+5 YEARS) SITE
ACCESS STUDY FOR A PROPOSED MALL



-----Subject site boundary (mall)

□ Study intersections

▤ Subarea study boundary

★ New development anticipated with trips generated, distributed, assigned to road network as with new subject mall tract development of 450,000 square feet of gross leasable area (GLA)

+3.5% ↑ ↓ Through traffic annual growth rates in the five year period to represent new development beyond study area (year 0 through year +5)

++++ Roads to be built by mall site developer

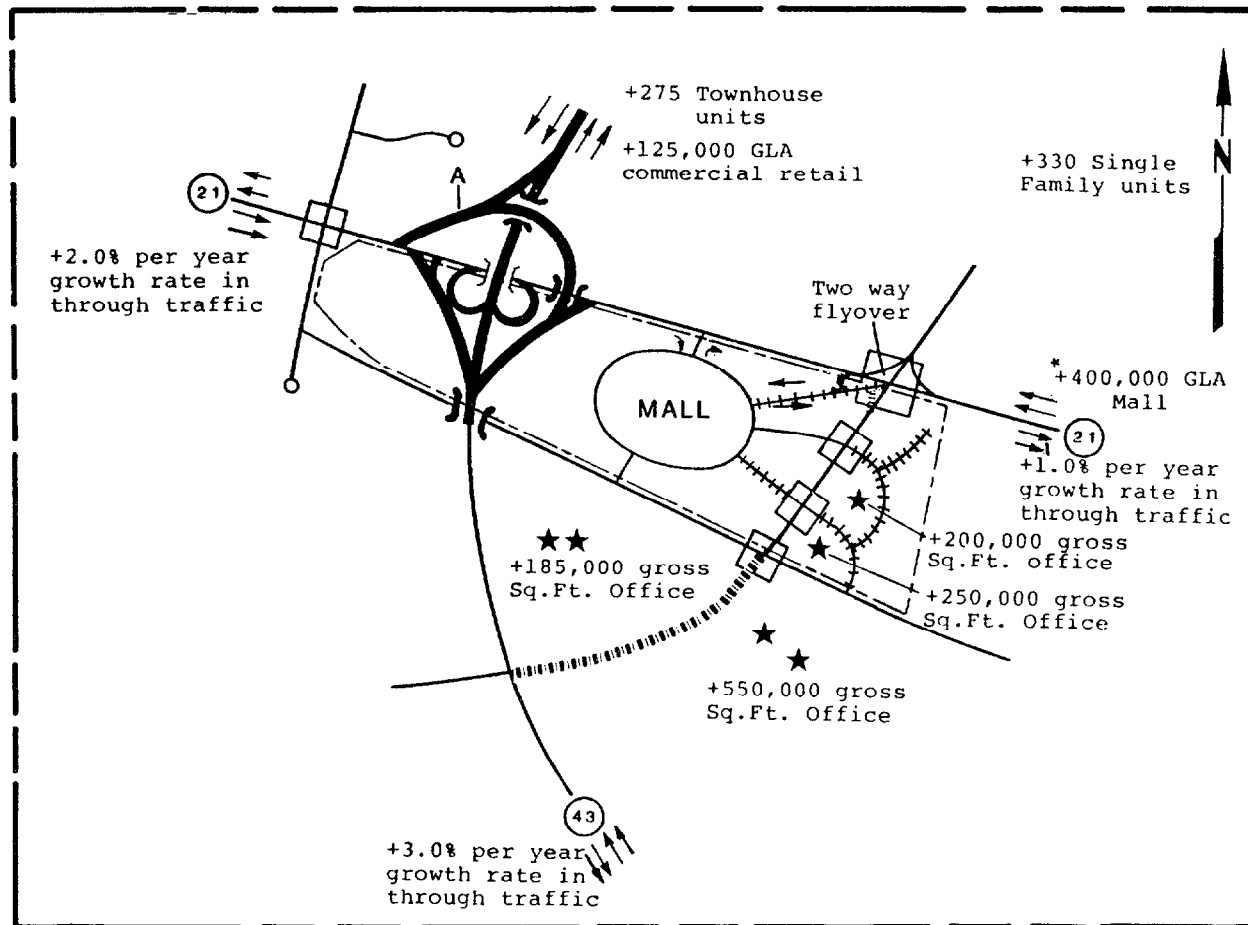
— Other new roads built by public agency

(21) Primary Arterial Roadway; four lane divided

(43) Primary Arterial Roadway; two lanes

(515) Secondary Roadway; two lanes

FIGURE 4b
TYPICAL PARAMETERS FOR A COMPLEX STAGE II (+10 YEARS) SITE
ACCESS STUDY FOR A PROPOSED MALL









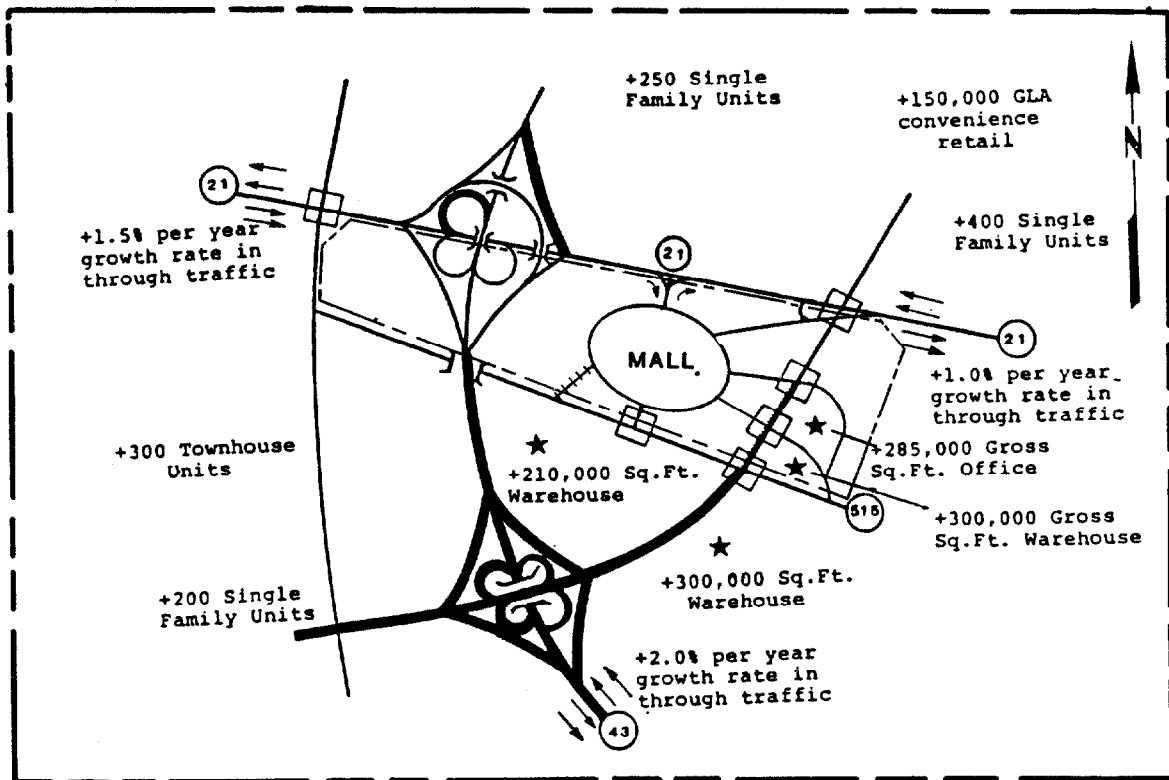
- Subject site boundary (new office development)
-  Study intersections, interchange and flyover
-  Subarea study boundary
- ★ New development anticipated with trips generated, distributed, assigned to road network as with new subject office tract development of 450,000 gross square feet of office space
- +3.0%  Through traffic annual growth rates between the +5 to +10 year period represent new development beyond study area
-  Two way flyover and other roads to be built by subject site developer
-  Road link build by other private developer
-  Other new roads/bridges built by public agency

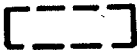
FIGURE 4c
TYPICAL PARAMETERS FOR A COMPLEX STAGE III (+20 YEARS) SITE
ACCESS STUDY FOR A PROPOSED MALL



----- Subject site boundary (new office development)



Study intersections, interchanges and flyover



Subarea study boundary



Other new development anticipated with trips generated, distributed, assigned to road network as with new subject office tract development of 585,000 gross square feet of office space

+2.0%



Through traffic annual growth rates between the +10 through +20 year period represent new development beyond study area



Other new roads/bridges built by public agency or other private developers



Other roads to be build by subject site developer

subject site development. Now the areawide traffic projections are probably available for the site development study projection years, although differences may still arise regarding long range road improvements; i.e. will these roads actually be built in 20 years?

Fundamentally, once this 20 year site access study is completed for a large site, it serves two purposes:

- Very specific site related access issues can be firmly understood and alternatives clearly evaluated to improve the decision making process regarding the subject site.
- Local officials can understand the relationship of the site related improvements to the subarea road network and the need (priority) for publicly funded road improvements, in combination with privately funded projects. In this way the privately funded site access study facilitates subarea and even regional road link decisions.

* Evaluate Data Needs

Having determined the study parameters, based on the project team and local official comments, available data are evaluated to determine if new data needs to be collected. New data collection is very much related to site access study needs and can vary significantly.

Examples of basic and complex study issues are described below as they relate to data needs.

Basic Site Access Study For An Office Building

- Perform 6 to 9 AM and 4 to 7 PM peak hour turning movement counts at key study area intersections since they represent the peak hour of the generator as well as the peak hour of the adjacent street traffic.
- Observe and record vehicle queues; direction/distance.
- Place (if ADT is of interest) automatic recorders on selected road links for a weekday or more if necessary.
- If the office building contains a 24 hour operation, such as a computer facility, trip generation counts may be made at a similar local building between 6 to 9 AM and 4 to 7 PM to verify a local, more accurate trip rate per 1000 sq.ft. of gross building area. Note: the survey building size and occupied space must be checked.
- If a signal warrant is to be checked the turning movement counts should be extended to 12 continuous hours.

Complex Site Access Study For An Office Park

Included in the complex site access study are the same items previously listed for a basic study (although more extensive in the number and complexity of locations), as well as the following.

- Employee residence zip codes, for a nearby office building representative of the office park, would be obtained, grouped by zip code and displayed on an area zip code map (i.e. percent distribution by zip code districts). Employee trips would then be assigned by zip code to the study area road network. This establishes a very realistic trip distribution pattern for the new office park. Trips are then assigned to the networks based on knowledge of the travel patterns in the area.
- For projects which deal with 20 year traffic projections and the possibility of changing trip distribution patterns over the years, gravity model runs made by areawide agencies can be used. Alternatively, the Quick Response System [3] or various software systems available commercially may be used with future areawide land use forecasts.
- Peak hour turning movement counts for complex studies may involve 10 to 20 intersections or ramp locations for which the data must ideally be recorded simultaneously. Data tabulations frequently are computerized.
- The 10 to 20 year analyses usually involve rather complex solutions which require a firm understanding of as-built and future roadways. Therefore construction plans, become extremely important to enable creative solutions to be developed.

* Tabulate Data: Calculate LOS

Newly collected data, such as zip codes and trip generation rates, are combined with other available data, as required, to establish a data base for technical analyses. The second task in this phase, calculation of the level of service, is very critical. The level of service discussion is presented in Appendix C.

[3]. "Quick Response System (QRS) Software Documentation"; Federal Highway Administration (HHP-22), January 1984.
see also: Quick Response Travel Estimation, (NCHRP 187), Transportation Research Board, Washington DC, 1978.

* Identify Site Access/Circulation Constraints And Opportunities

Having completed the technical analyses, site access pros/cons should be summarized in both written and graphic format. The following information should be included, as applicable:

- Level of Service results for peak hours
- Peak hour queuing problems
- Right-of-way restrictions/availability
- Special site access opportunities or constraints based on the analyses of current peak hour conditions
- General information i.e., roadway lane configurations, average daily traffic trends for the past five years, etc.

**PHASE II. PROJECT FUTURE PEAK HOUR TRAFFIC SITUATION
WITHOUT SITE DEVELOPED**

Phase II of the site access study process uses Phase I existing traffic and estimates future peak hour traffic. The projection process then results in a new LOS estimation and other analyses to identify future peak hour conditions without the site developed.

* Establish Past Growth Rate In Key Corridor(s)

Historical average daily traffic volume data, usually available from state or regional agencies, is most often used to determine the three to five year annual average rate of change (e.g. " + 4% per year increase in through traffic"). Unusually high rates of change must be carefully considered since such a rate may not be sustained over a long period of time. As areas reach maturity, corridor travel demand tends to stabilize due to peak period congestion and upstream bottlenecks; so growth rates in certain corridors may stabilize. Growth rates will vary by corridor. Alternatively, existing and future assignments from a regional planning agency can be used to develop growth rates to be applied to existing traffic.

For the basic site access study, the growth rate is not too critical an issue. For a complex mid to long term study, this can be a very critical technical issue for reasons described later in this section. Basically the issues are 1) the rate of increase for a complex study occurs over an extended time period and 2) annual increases in traffic "through" key study intersections are generated by new development "beyond" the study area. How far beyond, and to what extent annual increases represent adjacent new development, is usually an issue for

discussion and resolution.

Once resolved, annual rates are applied to existing peak hour volumes to achieve 10 to 20 year traffic projections. Care must be taken to adjust intersection volumes when corridor growth rates differ within the study area.

* Identify Changes In Road Network And Land Use Type/Density

These two items are not very critical in a basic site study. For example, the study area road network probably will not change too much in six months or a year. Nevertheless, changes must be considered because street patterns can be changed, signal phasing altered and key road links added, sometimes by another private developer. Also a new development nearby may influence the degree of change in level of service along with changes in the subject site. Once identified in a basic study, a roadway or traffic operational change may mean that the previously adjusted peak hour volumes must be re-adjusted to account for changes in travel patterns etc. Also, if the new land use is considered to be significant, peak hour trips can be generated, distributed and assigned to the road network. The trip generation, distribution and assignment process is described in Appendix C.

In the case of a complex site study with 10 or 20 year analyses, changes in the road network and land development can become very complex, as illustrated previously in Figures 4a, 4b and 4c. Road network assumptions at critical stages must be considered within a subarea context by state, regional or local planners to the degree necessary to complete a site access study, within its time and funding constraints. Land development changes are even more complex than the road network changes due to economic and market uncertainties. If a large subject tract is to be rezoned, the issues can become even more complex. Nevertheless, through careful discussions, reasonable guidelines can be agreed upon to permit road networks and "new" land use types, locations and densities to be selected. After all, this is a modeling process with the results allowing for alternatives to be tested. It is not a fixed process wherein a change cannot be evaluated at a later date. This being the case, as illustrated in Figures 4a, 4b and 4c three road networks and new land development "densities" can be identified.

Referring back to annual growth rates, in a complex study there is always concern about an issue called "double counting". For example, consider the following five step process:

- Step 1: Existing AM peak hour traffic volumes
(times)
- Step 2: An annual growth rate of 3.5% per year for 10 years
(plus)
- Step 3: Other "new" 10 year development trips generated,
distributed, assigned to the road network
(plus)
- Step 4: New subject site development trips generated,
distributed, assigned to the road network
(equals)
- Step 5: Total mid-term AM peak hour traffic volumes

Step		Step		Step		Step		Step
1	x	2	+	3	+	4	=	5

(Note that Step 4: Site Traffic was not included in Phase II; it is, nevertheless, important at this time).

The issue is: does the +3.5% per year growth rate over compensate or "double count" for other "new" development? A comparison to areawide 20 year traffic projections may indicate that the areawide projections are different. Experience has usually indicated +1 to +2 percent annual growth rates plus significant other "new" development results in reasonable projections. However, critics argue that this may not be true in high growth areas! A sensitivity analysis can be carried out to determine the degree to which annual growth rates influence the solutions or the share of the road improvements to be supported by the subject site developer.

* Project Phase I Peak Hour Traffic To Future Study Year

For a basic study, this is a simple task which involves calculations for a six month or one year period. The trip generation, trip distribution and trip assignment processes are described in Appendix C.

A complex study requires resolution of issues such as: staging year(s), road network(s), annual growth rate(s), and other new development(s). Then the calculations are performed to achieve projected AM/PM peak hour traffic. Obviously, factors can be used to convert peak hour traffic to average daily traffic in any year, if this information is considered important.

* Calculate Level of Service

The Highway Capacity Manual and/or other publications are used to determine the peak hour level of service without the subject site developed (See Appendix C).

* Identify Changes Between Existing And Future Situation

The following level of service comparison is now possible for a basic study:

Intersection No.	Phase I Existing		Phase II Future	
	<u>Level of Service</u>		<u>Level of Service</u>	
	(AM)	(PM)	(AM)	(PM)
1	A	C	B	C
2	A	D	A	D
3	B	D	D	F

For a complex study, this information would be available for each staging period (5, 10 and 20 years) in comparison to the existing situation. The results are used to identify locations which are congested in excess of Level of Service D in urban areas or Level of Service C in rural areas, without the subject site developed. Comments can vary depending on the results:

- Were the road networks properly selected?
- Were the annual growth rates sufficient or excessive?
- How bad is the level of service, as compared to the desired level of service, and what is causing it?
- Were the other "new" developments properly selected and located?

Regardless, Phase II provides an excellent representation of future conditions without the subject site developed. Besides level of service comparisons by intersections, certain technical issues are quite evident:

- Geometric design adequacies/inadequacies become apparent.
- Site access opportunities or constraints can be identified.

PHASE III. PROJECT PEAK HOUR SITE DEVELOPMENT TRAFFIC

Technical guidelines associated with the performance of Phase III tasks are described in this section. Certain aspects of the trip generation, distribution and assignment process are discussed in Appendix C.

* Select And Apply Appropriate Trip Generation Rates

This step estimates the site generated peak hour trips and is the same as described in Appendix C.

* Determine Trip Distribution Pattern And Assign Trips To Road Network

Having estimated the site generated peak hour trips, it must be determined to what degree the trips will use the study area road network. The trip distribution and assignment procedures are described in Appendix C.

The Phase III analyses result in site related peak hour traffic assignments which are combined with Phase II results.

PHASE IV. PROJECT FUTURE PEAK HOUR TRAFFIC SITUATION WITH SITE DEVELOPED

Phase IV of the site access study process establishes the peak hour situation with the site fully developed and occupied. Phase IV is based on the Phase II and Phase III results. The steps for conducting Phase IV are as follows.

* Combine Phase II Background Traffic With Phase III Assigned Traffic To Achieve Total Peak Hour Traffic

AM and PM peak hour network assigned traffic volumes for Phase II (without the subject site developed) are combined with Phase III AM and PM peak hour volumes (subject site generated trips) to achieve total peak hour traffic volume networks with the site developed.

For a basic study, where the road network does not change, this is a simple additive process. For a complex study, where the road network may change with the site developed, additional network assignments may be necessary to represent conditions with the site developed. Depending upon the circumstances, if as-zoned site development conditions are to be analyzed too, then a different set of road networks may apply because additional road improvements may be offered with the proposed development.

* Calculate LOS; And Compare To Phase I And Phase II LOS Results

Having combined the Phase II and Phase III peak hour volumes, Phase IV level of service is calculated for key intersections and ramps using the Highway Capacity Manual, and/or other publications.

* Identify Changes Between Phase I, Phase II And Phase IV Results

Level of service can now be summarized as indicated below for a basic site access study:

AM PEAK HOUR LEVEL OF SERVICE COMPARISON

Intersection No.	Existing Situation (Phase I)	Future Situation Without Site Developed (Phase II)	Future With Site Developed (Phase III)
1	A	B	C
2	A	A	C
3	B	D	E

These example level of service comparisons indicate that if LOS D was the acceptable LOS criteria, the LOS E would indicate a location which would operate in excess of an acceptable LOS as a result of the site being developed. This one level change in operating efficiency may be improved to a LOS D through further evaluation of intersection geometrics, signal timing/phasing or other improvements.

For a more complex multi-year study, the results would be compared on a similar basis, except that the analysis would consider each stage of development until build out occurs.

To illustrate a complex alternative, consider one intersection for a site being studied for as-zoned and as-proposed conditions (as-zoned refers to the current zoning, whereas as-proposed refers to the zoning requested by the developer). Figure 5 illustrates the AM peak hour levels of service comparison for the intersection.

While the results are rather simple, and meaningful, there are very complex implications associated with the findings that can only be understood through very careful review of the analyses. For intersection 1, as with as many as 10 or more key locations studied, the following can be inferred.

- * In the short term, assuming that a LOS D is acceptable, the intersection operates satisfactorily with or without the site developed either as-zoned or as-proposed. Note however that the LOS C without the site developed deteriorates to a LOS D for as-zoned conditions, but improves to a LOS C for as-proposed conditions. This "improved" LOS with the as-proposed option could be a function of several factors.

FIGURE 5
AM PEAK HOUR LEVEL OF SERVICE COMPARISON FOR INTERSECTION 1

CONDITION	AM PEAK LOS [1]	ROAD NETWORK CONFIGURATION
<u>Existing Situation</u>	A	1
<u>Short Term Conditions</u> <u>(+5 Yrs)</u>		
Without Site Developed	C	2 (1 + committed/planned + 5 year improvements)
With Site Developed As-Zoned	D	2 + as-zoned improvements
With Site Developed As-Proposed	C	2 + as-proposed improvements
<u>Mid Term Conditions</u> <u>(+10 yrs)</u>		
Without Site Developed	D	3 (2 + committed/planned + 10 year improvements)
With Site Developed As-Zoned	E	3 + as-zoned improvements
With Site Developed As-Proposed	D	3 + as-proposed improvements
<u>Long Term Conditions</u> <u>(+20 yrs)</u>		
Without site Developed	F	4 (3 + committed/planned + 20 year improvements)
With Site Developed As-Zoned	F	4 + as-zoned improvements
With Site Developed As-Proposed	E	4 + as-proposed improvements

[1] AM Peak Hour Level-of-Service at Intersection 1

- the as-proposed density may generate fewer AM peak hour trips than the as-zoned density, so assuming the road network is essentially the same for both the as-zoned and as-proposed, the LOS would obviously improve.
 - the as-proposed road network may be significantly more efficient or improved as compared to the as-zoned road network even though the trips generated in each option are similar. This would also improve intersection level of service.
- * In the mid-term, LOS D is achieved without the site developed. With the site developed as-zoned, a LOS E is achieved which may mean that public funds are necessary to reduce the LOS E to a LOS D or better. With the site developed as-proposed, a LOS D is achieved. This level of service is achieved primarily by the roadway improvements proposed by the site developer.
- * In the long-term, with or without the site developed as-zoned, a LOS F is achieved, making public expenditures necessary to correct the situation. With the site developed as-proposed a LOS E is achieved prolonging the point at which the need for public expenditures would occur. A LOS D may be achievable, but very significant additional roadway improvements may be necessary which may not be economically feasible.

PHASE V. DEVELOP SITE ACCESS RELATED SOLUTIONS

Phase V of the site access study process is the creative phase which identifies site access related improvements which the developer agrees to construct. This phase consists of two major tasks as described below.

* Evaluate Alternative Solutions To Achieve Acceptable Levels Of Service

Having completed the level of service peak hour comparisons, an assessment should be made of the need to incorporate changes in land use or transportation improvements, including TSM actions, assuming Phase IV results were accurately analyzed.

For a basic site access study, the evaluation process is not too difficult because of the limited number of alternatives. Typical changes which could be considered are:

- Reassessment of trip generation rates or the trip distribution pattern.
- Consideration of TSM actions to reduce peak hour traffic and improve level of service.

- Consideration of modifications to key intersections or road links to include widening, signal timing/phasing changes, channelization modifications, changes in ingress/egress points, or the number of entrances, additional lanes, etc. Other factors such as access related improvement costs, ease of implementation, possible citizen reaction, acceptability to state/local officials, level of service improvement, etc., should also be considered. In some instances, re-analysis is necessary to evaluate the pros/cons of alternatives. Occasionally, a significant change in land use type or density may be necessary.

For a complex site access study, the evaluation process is far more extensive because of the greater number of factors which can influence the results. For example, typical changes, in addition to those described for a basic study, may include the following:

- Significantly different new land use development programs.
- Significantly modified road networks to include flyovers, tunnels, etc. to alter the access situation. Preliminary design studies may be considered necessary to evaluate possible solutions.
- Implementation of major TSM programs to significantly influence site generated traffic volumes by changing travel characteristics.

These changes may constitute rather extensive changes in the technical analyses performed. It should be noted that such a major re-evaluation should only be considered after a review of long term LOS results. In other words, Phases II, III and IV in a major study may only involve a 20 year PM peak hour projection and LOS evaluation at selected locations. If the results are unacceptable, then a major re-evaluation is performed -- or even a "reverse" analysis is performed to identify alternative land use options that can be supported by the road network. Then, after the major re-evaluation, Phases II, III and IV are considered for short term and mid-term analyses.

* Select Preferred Solution; Document Findings

Having completed the site access analyses, the pros/cons of various alternatives and the preferred solution should be discussed with the project team. Coordination with on-site circulation details, should be considered. Technical modifications may be necessary to make the off-site access improvements compatible with on-site circulation improvements to

include parking facility (lots, decks, garage) access points. Once this is accomplished, then the final site access study findings can be documented in written and graphic format.

This phase constitutes the principal technical analyses associated with the preparation of a site access study. The remaining phases depend upon the original purpose of the study. Since most site access studies proceed with local review and either approval or disapproval for the proposed action, this is the context within which the two remaining phases are described.

PHASE VI. NEGOTIATE SITE ACCESS

Phase VI of the site access study process is necessary since the solutions may change after consultations with the local officials. Further analyses may be necessary. The two tasks in Phase VI are as follows.

*** Negotiations Between Local Officials And Developers To Reach Agreement On The Proposed Development**

Following distribution of the site access study findings, presentations and/or workshop meetings should be held to explain technical aspects of the study. Since the issues can become quite complex for explanation and discussion within normal meeting times, every effort should be made to use effective audio-visual techniques to clarify issues and focus the discussion. The review process is usually subject to local and state regulations. Technical issues may be raised regarding (1) analyses which were not performed, (2) techniques used in the technical analysis process and (3) assumptions concerning trip generation rates, etc. used in the process.

*** Supplemental Technical Analyses To Resolve Outstanding Issues**

The type and extent of supplemental analyses depends upon the issues raised. Occasionally, technical site access related differences are simply negotiated. Land use, utilities, height, or other issues constitute the remaining items for resolution. When site access remains an issue, it may involve discussions regarding one or several of the following issues:

- Proposed land use/density is not acceptable to the local planning staff.
- Trip generation rates are unreasonable or do not conform to local rates.
- Trip distribution patterns/changes over time are not properly documented.

- The LOS calculations are either incorrect or the locally preferred technique was not used or properly interpreted.
- TSM actions were not used to the extent deemed necessary or assumed effectiveness of TSM actions were too optimistic.
- Private share of improvements (costs) are not sufficient.
- Site plan details regarding building size/location, parking facility operations, and pedestrian improvements, are unacceptable.

Appropriate technical analyses must then be performed to resolve these issues.

PHASE VII. IMPLEMENT PROJECT/ACCESS IMPROVEMENTS

Phase VII of the site access study process occurs after agreement between the developers and the local officials is reached. Tasks that may be required in Phase VII are as follows:

*** Assist Site Engineer In Preparing Construction Plans**

Assist the developer, site engineer, and architect in the preparation of final site plans and construction plans for roadways, parking facilities and traffic operational measures to aid implementation. A coordinated effort is necessary to ensure that both public and private access improvements are implemented on a timely basis especially for projects to be constructed over 10-20 years. On-site circulation improvements are also carefully coordinated with building/entrance locations, as well as parking facilities, i.e. lots, decks, garage, to ensure on-site efficiency and interface with the off-site local road network.

*** Develop Signalization Plans/Specifications (If Applicable) For Bid**

If new or modified signalization is required, plans and specifications can be prepared for bid. This ensures that the plans are coordinated with publicly funded improvements or existing traffic operational and roadway features. Since the project developer occasionally pays for all or a portion of new signal installations, this responsibility for development of plans and specifications can be considered appropriate by local agencies.

* Privately Funded Roadway Or Traffic Operational Improvements Implemented

The final step of the site access study process is implementing the physical site access related improvements which may encompass roadway or traffic operational changes, fully or partially funded by the site developer. For basic site access studies, this may involve the following improvements, often funded totally by the developer:

- An additional right turn deceleration lane at a key intersection to improve peak hour efficiency.
- Modification to a traffic signal installation.
- Site plan modifications to improve entranceway ingress/egress efficiency.

For complex site access studies, the previously mentioned improvements are typical of projects totally funded by the developer, while the following, more expensive improvements, are typical of those usually partially or fully funded by the developer.

- Construction of significant multi-lane roadway sections, connecting major or minor arterials.
- Construction of additional lanes to widen major roadway corridors.
- Installation of traffic signals, including interconnection cable.
- Construction of flyovers or tunnels to improve peak hour traffic conditions.
- Construction of a complete or partial interchange.

These facilities are built to public agency standards with future maintenance usually funded by public agencies. It should also be noted that non-highway related improvements or actions are sometimes funded, e.g. ridesharing programs or shuttle bus service.

[This page intentionally left blank]

IV. CONCLUSIONS

The site access study process, as described phase by phase for both basic and complex studies, is a widely used technique for resolving land use and transportation issues. With the increasing emphasis on shared public and private participation in transportation and TSM type improvements, it is clear that the technique is also an important element in the investment decision-making process of the developer.

This places a great deal of responsibility on not only the developer, but on the agency or person(s) responsible for the negotiations. It also requires that the technical process be more widely understood and technically sufficient to provide meaningful results within available budget and time constraints.

The general process described in this handbook has been used for some time. However, its importance in the transportation planning process and its impact on certain local, sub area and regional planning decisions has sometimes been overlooked. Due to the wide range of issues involved in site access studies it is difficult to offer more than general guidelines in a handbook of this type. Attempts to overcome this have been made by presenting four case studies in Appendix D. This does not, however, address all problems and situations that may arise.

Complicating the situation further is the fact that issue identification alone is difficult. For example, a project may appear to have no access problem, but through a series of events or oversights very serious access issues may arise. The access issues may become more complicated due to citizen opposition, site constraints which influence on-site circulation, or parking facilities or other technical elements. And of course, the negotiation process and implementation stages may introduce new issues for technical resolution.

Besides recognizing the importance of the site access study process, it is also important to realize that certain technical factors in the process can significantly influence not only the level of service results but the entire site plan land use type/density and related roadway and traffic operational improvements, including TSM actions. One of the most important elements is the trip generation rates which were specifically evaluated through case studies for level of service sensitivity in this handbook.

Of course, other elements of the study process such as the number of gross square feet per (office) employee, mode of arrival (percentage), vehicle occupancy and trip distribution

patterns can also individually or in combination affect level of service and other study findings.

In view of the technical complications associated with site access studies, the guidelines identified in this handbook should be modified to coincide with local or state ordinances and approved policies.

SUMMARY OF CASE STUDIES

The site access study process described in the previous chapters was used to conduct four case studies. The principal reason for performing the case studies is to show the application of trip generation rates and to illustrate how peak hour level of service is influenced by a change in trip generation rates. A secondary purpose was to illustrate the sensitivity of other variables to the peak hour levels of service. The four case studies are described in Appendix D. The results are summarized below.

*** Variation In Trip Generation Rates**

Case Study No. 1, a basic site access study, indicated that the key study intersection was significantly improved from a LOS F to LOS E by a 25% reduction in the office and motel trip rates. At other less heavily traveled intersections, this same reduction in trip rates did not change the levels of service!

Case Study No. 2, a basic site access study, indicated that a 10% increase or a 10% decrease in trip generation rates did not change the levels of service or level of efficiency at any intersection studied.

Case Study No. 3, a complex site access study, indicated that with an increase in trip generation rates from the actual study rates to the updated NCHRP 187 or ITE rates, the levels of service at all five intersections were reduced significantly.

Case Study No. 4, a complex site access study, used a wide range of trip generation rates, influenced by a change in other key factors. It indicated that the most heavily traveled intersection was influenced by one level of service, either better (LOS E to LOS D) or worse (LOS D to LOS E), by the various changes in trip rates. The less critical intersections were influenced by the rates but the levels of service never became worse than LOS D. Changes in mode of auto arrival (an increase from 81% to 90%), auto occupancy (a reduction from 1.25 to 1.1) and arrival / departure rates (an increase from 55%/50% to 65%/60%) resulted in less efficient peak hour operating

conditions by one level of service.

* Variation In Trip Distribution Patterns

Case Study No. 1, Condition 3, indicated that a reduction from 75% to 55% in the site trips distributed through a key intersection did not change the level of service at the key intersection, but it was sufficient to change a LOS E to LOS D, a range of 90 units at the second most important intersection.

* Variation In Normal Growth Rate

Case Study No. 1, Condition 4, indicated that a reduction in normal annual growth rates on the major corridor - and a lesser reduction in mall site traffic - produced a very much improved level of service at the key intersection, from a LOS F or LOS E in the PM peak hour for three conditions to a LOS B/C in the PM peak hour for Condition 4.

While the case studies do not illustrate a direct relationship between a change in trip rates and level of service, it should be apparent that the rates can seriously influence the results.

APPENDIX A
DEFINITIONS: SITE ACCESS STUDY TERMINOLOGY

The following definitions are presented to clarify the technical terminology associated with site access study analyses.

Capture Rates for Pass-by Traffic: Proportion of trips attracted to the development from traffic normally passing-by the site.

"Committed" Development: New land use projects for which site location, type and density are firmly established for construction.

Committed Roadway/Traffic Operational Improvements: New roadway or traffic operational improvements for which plans are firmly established, and funded, for construction.

Existing Zoning: When applicable, by local ordinance, the currently approved land use type and density by Floor Area Ratio (FAR) which could be built on the subject site by right.

"Internal" Trips: Site generated trips which occur between two or more land uses located on the subject site with both trip ends on-site.

Level of Service (LOS): A set of criteria that describes the degree to which an intersection, roadway, weaving section or ramp efficiently serves peak hour and/or daily traffic. LOS definitions are presented in Appendix C.

Metropolitan Planning Organization (MPO): An agency responsible for regional (metropolitan) planning functions including transportation, and land use as it relates to member jurisdictions.

Mode Split: The percentage split of site generated trips which utilize various modes of travel to access a site, i.e. auto, bus, subway, walk, bicycle, etc.; with the extent of use depending upon the degree to which the service or facility is available.

Normal Growth Rates: The annual rate of change in through traffic on principal off-site roadways as determined using historical 24 hour average daily traffic volumes.

"Normal" Site Access Study Process: Site access related analyses initially performed with fixed, or a certain number of

land use types/densities for which selected site access improvements are developed to serve the preferred land use.

"Off-Site" Access: The road network beyond the site's boundary which provides vehicular site access.

"On-Site" Circulation: Vehicular network which primarily accommodates site generated traffic within the site boundary and includes not only roadways, but parking lots, decks, and garage travelways.

"Planned" Development: New land use projects for which site plans are being or have been developed, but no firm date has been set for construction. Completion is expected within the study period.

"Planned" Roadway/Traffic Operational Improvements: New roadway or traffic operational improvements for which plans are being or have been developed but no firm date has been set for construction. Completion however, is expected within the study period.

Project Staging: The time period, (years), when selected land use densities will be occupied, therefore generating site traffic. Staging years may, as an alternative, be selected on the basis of the road network to be studied rather than selected on the basis of land use densities.

Proposed Zoning: The land use type and density proposed to be developed which necessitates re-zoning (when applicable) the land from the as-zoned condition; also described by Floor Area Ratio (FAR).

"Reverse" Site Access Study Process: Site access analyses performed with a fixed, or a certain number of road networks selected, to determine the range of land use types/densities which can be served by the preferred road network.

Roadway Capacity: The maximum number of vehicles which can pass a given point during a specified time period under prevailing roadway and traffic conditions.

Signal Warrant: The Manual on Uniform Traffic Control Devices for Streets and Highways prepared by the U.S. Department of Transportation (1978) presents requirements (warrants) that should be met for a traffic signal to be installed.

Study Area: The road network and land area which encompasses

the principal intersection, road links, ramps, etc. and new land use developments of primary concern in a site access study.

Trip: A single or one - direction vehicular trip with either the origin (outbound) or destination (inbound) or both inside the study area. Each trip has two trip ends.

Trip Assignment: After applying the geographic corridor percentage total peak hour generated trips, the resulting corridor trips are assigned to the study area road network. The process is repeated for inbound (to) and outbound (from) site trips for each land use type.

Trip Chaining: A single one directional vehicular trip with intermediate stops. For example an AM peak hour vehicle (trip) originating at a residence would stop at a retail convenience store, then proceed to work at an office site. Reverse trip chaining may occur during the return PM peak hour trip. Various other trip chaining combinations may occur which tend to complicate trip purpose and trip generation.

Trip Distribution: The geographic distribution of trip ends attracted to the site, usually expressed as a percentage of the total site trips generated via (and assignable to) major site access corridors.

Trip Ends: The total of all trips entering plus all trips leaving a specific land use within a specific time period.

Trip Generation Rate: The ratio of total trips or trip ends generated (from the site) or attracted (to the site) during a specific time period, per some measure of related land use activity, such as :

- trips per room (hotel)
- trips per 1000 gross square feet (office space)

APPENDIX B ISSUES AND TRENDS IN SITE ACCESS STUDIES

A site access study describes how traffic generated by either new land use(s) or replacement land use(s) will be served by an existing or future road network. This Appendix presents the reasons for conducting a site access study and discusses the major issues and emerging trends in site access studies.

ISSUES - SITE ACCESS STUDIES

A private developer commissions a site access study in order to satisfy either his own needs or to fulfill public agency requirements, or for both reasons. The study is usually performed to meet one of the following technical needs.

- 1) To obtain agency approval to re-zone a specific tract of land; from a residential density to an office density for example.
- 2) To obtain site plan approval for development of a tract as-zoned.
- 3) To obtain approval of a special exception in land use or the site plan; for example adding a convenience retail counter to an existing service station.
- 4) To aid in negotiations for the acquisition of right-of-way by the public agency responsible for roadway improvements, i.e. for widening a roadway in front of a shopping center, which would significantly change vehicular access patterns and reduce the number of retail parking spaces.
- 5) To aid in the resolution of different opinions regarding possible land use development options. For example, a public agency may consider that a tract can only be developed as a single family residential use whereas a developer may consider townhouse offices a reasonable alternative. A site access study will be used to compare the critical issues with the matter resolved with or without court action.

In the previous cases, the proposed land use density is given, whereas in the following instances, land use options vary.

- 6) To aid a developer in evaluating potential development benefits and costs in advance of the actual purchase of a specific tract of land. If the tract is not developed,

practical land use mixes, associated road networks and road costs will be identified by performing a site access study for the developer. If the tract is already developed re-use options will be evaluated and similar findings developed. Usually, selected land uses densities are tested for roadway network implications. If a reasonable land use density is considered to be achievable, a firm option or actual purchase of the tract will occur. Then, if appropriate, a rezoning study will be instituted with a more refined site access study being performed for the preferred development plan.

For very unusual tracts, which are almost inaccessible a reverse process can be used by holding the future road network constant and determining the land use(s) density which can be efficiently accommodated on the subject tract.

The last example of a need for a site access study occurs when a site plan is being developed with the land use fixed, but with variable building shapes and locations on the site plans.

7) Recognizing that there is a relationship between "on-site" circulation patterns (within parking lots, decks or garages) and entrances to the "off-site" road network, a site access study is occasionally necessary to aid in the resolution of "on-site" issues related to parking facilities.

With an increasing awareness by developers of parking costs for decks and garages, and the need to have efficient ingress/egress for competitive market conditions, "on-site" circulation issues are more frequently being studied in combination with the site access study. Sometimes "off-site" access can be enhanced by changes in "on-site" circulation.

TRENDS - SITE ACCESS STUDIES

While site access studies have been important in the past, there are three reasons why such studies will be even more critical in the future.

First, the economic situation has changed significantly throughout the United States with respect to the ability of public agencies to fund major roadway improvements. An obvious source of funds to aid public agencies in the construction of major roadway improvements is for the developer of sizable commercial tracts to build a portion of a roadway or to contribute to a fund for future road improvements. Site access

studies are necessary to quantify the nature and extent of road improvements to ensure that reasonable and effective roadway improvements are made. Such studies also enable cost sharing to be more accurately discussed which expedites negotiations and implementation. For example, the site access study process can be used to define the pro-rata share of a road improvement cost between two private developers in terms of traffic generated by each developer's tract. The studies also allow incentives to be tested in case additional density is to be allowed for additional privately funded road improvements. Examples of the benefits of this emerging process have been well documented so the trend is real and the results are actually being realized. To what degree the process will be intensified or expanded depends on a variety of factors - one of which is a well conceived and documented site access study. When effectively implemented such a program could have significant benefits in reducing public agency road costs.

Secondly, we are midway in the 1980's (1985), through a decade-long evolutionary change in real estate finance. Real estate is evolving into a mature investment medium that is approaching equal footing with stocks and bonds. Through the 80's the real estate lending community will become much more integrated, with the roles of individual types of institutions blurring. This is also leading to major universities instituting real estate schools to better prepare graduates for far more complex financial issues in land development than have previously existed. Since location and accessibility are so important to successful development projects, the ability of the site access study process to aid in the resolution of complex issues is especially critical.

Thirdly, while the real estate revolution in the 80's has been in finance, significant changes have also occurred in various land uses. Trends have become apparent in the last five years and will continue to be forced in the marketplace through the latter 80's.

Table B-1 summarizes the major market shifts. Site access studies are applicable to most of the items as discussed below:

Item 1: With increasing concern about building quality, design and amenities there is a greater awareness of accessibility, particularly if developers must pay for significant roadway improvements.

[5]. "Emerging Trends in Real Estate:1985"; Real Estate Research Corporation; November 1984 for Balcor/American Express, Inc.

[6]. Ibid.

TABLE B-1
MARKET SHIFTS IN THE 80's

The real estate revolution of this decade is in finance, which has been amply described earlier in this Appendix. However, changes are also occurring in various land uses, as summarized below. All of these trends have become apparent in the last five years and will continue to be forces in the marketplace through the latter 80's.

1. A pronounced upgrading in construction quality for all types of buildings and increased focus on both design and amenities.
2. Greater energy efficiency in new and retrofitted buildings.
3. Mixed-use developments becoming more the rule than the exception.
4. Dramatic rise in rehabilitation, spurred by tax incentives and changing consumer tastes.
5. Revitalization of one downtown after another, generally led by big-city examples but extended now to small cities across the county.
6. Blurring of office and industrial land use categories, typified by the rise of business parks.
7. Introduction of so-called "smart" office buildings, providing sophisticated control and monitoring of energy utilization, safety, telecommunications and maintenance systems. (By 1990, many office buildings will be "geniuses".)
8. Real estate time-sharing coming of age, with 75,000 to 100,000 new buyers a year.
9. Rapid expansion of all-suite hotels, probably to the point of market saturation.
10. Major hotel chains creating spinoffs to penetrate both higher- and lower-end markets; here, success will be mixed.

TABLE B-1, Continued

11. Proliferation of specialty and festival retail centers, once again starting in larger cities and moving rapidly into second-tier markets.
12. Continued focus on off-price retailing, with success tempered by countermoves on the part of traditional retailers.
13. Downsizing of new housing units in response to affordability problems and changes in household characteristics.
14. Condominiums capturing a bigger share of the residential pie.
15. Renewed developer and investor interest in market-rate multifamily rental housing.

SOURCE: Emerging Trends in Real Estate: 1985
Real Estate Research Corporation, November 1984 for
Balcort/American Express Inc.

Item 3: Mixed use developments are being more frequently considered in site access studies, with a wide range of land uses and densities, as well as shared parking possibilities and on-site (or internal trip making between on-site land uses). Such site access studies must be carefully performed to fully understand critical issues. Very little data are available to recommend a method for estimating reduced driveway volumes because of combined uses. [7] This means that trip generation rates for mixed use developments must be carefully considered. And, of course, a number of other technical elements are of similar complexity because historical data are not available. Developers of mixed use projects frequently contribute to the funding of public roadway improvements.

Item 4: A dramatic rise in rehabilitation raises complex site access study issues because existing land uses are being upgraded; replacing existing traffic volumes with traffic generated by new uses and sometimes density changes. Private contributions for new roadway improvements are not as easily negotiated in this case because the re-use may be allowed under current zoning.

Item 5: Revitalization in downtown sectors co-mingles site access, parking and, when applicable, transit issues making it necessary to study not only site access but parking demand and alternative modes of travel.

Item 6: Industrial space is more frequently being used for general office space, making the trip generation rates for office space and industrial space more equal. In the past, industrial space was more predominantly related to warehousing and storage so the generated trips were significantly lower than for general office space. This change is occurring due to increase in business parks and competitive market conditions. This variation in trip rates is frequently an issue in site access studies. The industrial space with office uses can be compared to a multi-tenant office building. However, a single tenant office building has different characteristics such as higher square feet per employee. Further, corporate policy can be used to maximize the use of ridesharing and TSM actions to reduce peak hour traffic without creating marketing problems associated with a multi-tenant office building.

7. Buttke, Carl H. ; Using the ITE Trip Generation Report ; July 1984 ; pp 14.

Item 7: Telecommunications and 24 hour computer operations in office buildings will influence (reduce) the number of peak period generated vehicular trips and trip making characteristics.

Item 10: Hotel chains have created new market facilities with all suites and no on-site restaurants or meeting room facilities. This could influence the number and type of generated vehicular trips, which is an essential ingredient of site access studies. These uses generate moderate traffic volumes during the peak hours and require site access studies less frequently. Such studies are associated with on-site circulation, parking facility needs or shared parking with nearby office buildings.

Item 11: Specialty retail (often waterfront) centers require careful consideration since the combination of retail uses can complicate site access study analyses. For example sporting (exercise, athletic) clubs are being integrated into office buildings. Children's day care centers, which are usually developed on isolated tracts, are being integrated with retail centers and office complexes. Service stations with maintenance bays are being converted to self service gas and go with computerized payment. Drive-in banks co-exist with the bank building or are located within retail centers or building complexes. Fast food restaurants are incorporating drive-in windows and breakfast openings which coincide with AM peak hour highway traffic conditions.

Item 12: Off-price retailing or outlet malls raise trip generation issues because very little data are available for this new retail use. New traffic studies are necessary to understand trip making characteristics.

Item 14: Besides residential condominiums, office condominiums are more frequently being constructed. The trip making characteristics for this new use are not fully understood and yet this use is frequently involved in site access studies. Developers of residential uses usually provide basic roadway infrastructure but cannot afford to provide major roadway improvements such as flyovers, interchanges etc. to the degree commercial or retail developers can.

In addition, there is a growing concern that the public planning process seems unable to cope with suburban growth and resultant traffic congestion. Possibly more effective solutions can be achieved through greater private sector involvement and public - private cooperation, which can be illustrated by:

- Negotiated ad hoc agreements with private developers.
- Regulatory requirements for developer/employee involvement, such as the Los Angeles parking ordinances and the Placer County ordinance.
- Private sector led strategic planning and lobbying such as Houston's Mobility Plan and Dallas' Transportation Task Force, Los Angeles' Coalition for Rapid Transit, Californians For Better Transportation and the Tysons Transportation Association in Fairfax County, Virginia.
- Mechanisms to facilitate cooperation among private groups such as transportation management associations and employers' associations. [8]

In summary, emerging trends are being considered in current site access studies, but with more "hybrid" land uses and development concepts comes the need for improved public-private negotiations. This requires more carefully conceived site access studies and updated daily and peak hour trip generation rates for new and frequently used land uses.

8. "Mobility for Major Metropolitan Growth Centers: A New Challenge for Private-Public Cooperation"; workshop-conference, Los Angeles, CA; November 29-30, 1984

APPENDIX C TECHNICAL BACKGROUND

This Appendix describes trip generation, trip distribution/assignment and level of service estimation procedures. The procedures noted herein are not all inclusive and locally acceptable procedures should be used where applicable.

TRIP GENERATION

There are five steps to consider for selecting a trip generation rate, and the final decision will be a function of the proposed land use project and its complexity.

For example, for a basic study which involves 25 new townhouse office units, consider the following steps.

- Step 1: Check for available local trip generation rates, i.e. vehicular trips per unit per day, per AM and PM peak hour; inbound and outbound for a comparable site. Note that townhouse office tenants may vary significantly from project to project which may result in a wide range of trip rates since the occupants were so dissimilar.
- Step 2: Check the updated NCHRP 187 rates for an applicable range in trip rates. [9]
- Step 3: Check the ITE trip rates. [10,11]
- Step 4: Develop a special trip rate if local rates are not available by surveying a comparable townhouse office project for peak hour and daily traffic volumes on a typical weekday.
- Step 5: Select the most appropriate trip rates and apply to the 25 units proposed to achieve total plus in and out site trips to be generated on a peak hour and daily basis. Since a townhouse office tenant mix may vary, provide for a possible range in trips generated. If a variation may influence the results, it should be tested.

-
9. Development And Application Of Trip Generation Rates, Federal Highway Administration (HHP-22), January 1985
 10. Buttke, Carl H., Using the ITE Trip Generation Report, Institute of Transportation Engineers, July 1984
 11. Trip Generation, An Informational Report, ITE, Washington D.C., 1982

For a complex office development to be built over 15 to 20 years, another alternative is suggested, since updated NCHRP 187 and ITE office trip rates do not always account for a variation in TSM actions, which influence the rates. This technique as described below, provides an excellent basis for understanding the rates and how they may change due to certain development criteria; or changes due to a variety of other factors, especially over a 15 to 20 year period. For non-office land uses, one of the five steps listed for a basic study should be used.

Table C-1 illustrates the technique applied to an office building containing 62,000 gross square feet of proposed office space.

- Step 1: Obtain the gross floor area (square feet) from the developer or architect.
- Step 2: Request from the developer or architect an estimate of the number of gross square feet per employee. This may range from 200 in a pure governmental office building to 275 to 325 in a corporate head-quarter's building. It may also vary as to whether the space is to be leased or owned by a company. Companies generally make far more efficient use of leased than of owned space. This is particularly true for corporate headquarters, which tend to have 275 square feet per employee in their own building and 200 to 220 in rented space.[12] If the user is not sure of the square feet per employee, then sensitivity tests can be conducted to determine the impact of this variable.
- Step 3: Divide the gross square feet (62,000) by the gross square feet per employee (275) to obtain the total number of employees (225).
- Step 4: Determine the mode of arrival, as a percentage of the total arrivals, for employees traveling to the building. Such information may be available from other nearby studies or a special survey, but most typically this is an experienced judgment item. Note that the mode of arrival may change significantly over time due to new modes of travel being available, or movement links being made more efficient/safe. Information from areawide agencies can be useful.

12. Emerging Trends in Real Estate: 1984, Real Estate Research Corporation, November 1983.

TABLE C-1
EXAMPLE OF TECHNIQUE FOR
ESTIMATING OFFICE BUILDING PEAK HOUR GENERATED TRIPS

o	GROSS FLOOR AREA (SQ.FT.)	62,000	[1]		
o	SQ.FT./EMPLOYEE	275	[2]		
o	TOTAL NUMBER OF EMPLOYEES	225	[3]		
o	MODE OF ARRIVAL	<u>PERCENT SPLIT</u>		<u>NUMBER OF PERSONS</u>	
	Bus	4.0		9	
	Subway and Light Rail	0.0		---	
	Walk/Other	1.0		2	
	Vanpool	3.0		7	
	Auto	<u>92.0</u>		<u>207</u>	
		100.0	[4]	225	[5]
o	AVERAGE DAY EMPLOYEES (with 10 percent absentees)				
	Vanpool			6	
	Auto			186	[6]
o	VEHICLE TRIP ESTIMATES	<u>VEHICLE OCCUPANCY RATE</u>		<u>PERSONS</u>	<u>VEHICLES</u>
	Vanpool	7.0		6	1
	Auto	1.25 [7]		185 [8]	<u>143</u> [9]
					144
o	AM PEAK HOUR	<u>ARRIVAL RATE</u>		<u>VEHICLE TRIPS</u>	
	Employee Vehicle Trips	55% [10]		79 [11]	
	Non-employee vehicle trips (0.28 trips/employee)	10%		6 [12]	
	Total inbound trips			85 [13]	
	Total outbound trips			<u>15</u> [14]	
	AM Peak Hour 2-way trips			100 [15]	
o	PM PEAK HOUR	<u>DEPARTURE RATE</u>		<u>VEHICLE TRIPS</u>	
	Employee Vehicle Trips	50% [16]		72 [18]	
	Non-employee vehicle trips (0.28 trips/employee)	20% [17]		12 [19]	
	Total outbound trips			84 [20]	
	Total inbound trips			<u>15</u> [21]	
	PM Peak Hour 2-way trips			99	
o	VEHICLE TRIP RATE/1,000 SQ.FT. (2-WAY)				
	AM Peak Hour	1.61 [22]			
	PM Peak Hour	1.58 [23]			

Step numbers in [Brackets]

- Step 5: Apply the mode of arrival percentage to the total number of employees to achieve the total number of employees arriving by mode on a typical day; assuming full employment.
- Step 6: A 10 percent reduction factor is applied to the total number of employees arriving by vanpool and auto results to reflect the fact that on a typical weekday, 10 percent of the employees will be absent due to sickness, vacation, traveling on business etc.
- Step 7: Select reasonable auto and vanpool vehicle occupancy rates in persons/vehicle using data from areawide agencies.
- Step 8: Select the number of persons arriving by vanpool and auto from Step 6.
- Step 9: Divide Step 8 persons by the Step 7 occupancy rates to determine the number of vehicles (other than buses) arriving at the site.
- Step 10: The percentage of employee vehicle trips arriving during the AM peak hour is selected using historical, survey, or information from areawide agencies. This is an important percentage which may range from 45 to 65 percent. For example, an office building with 24 hour computer operations will create a significantly lower AM peak hour percentage than a normal office building.
- Step 11: Applying the Step 10 percentage to the Step 9 average day vehicle trips results in the AM peak hour employee vehicle trips.
- Step 12: To account for non-employee trips such as visitors, maintenance or delivery trips per employee during the AM peak hour, a rate is selected based on historical, survey, areawide data or experienced judgment. In the example 0.28 trips per employee was selected along with 10 percent of the trips arriving during the AM peak hour.
- Applying the 0.28 trips per employee to the 225 total employees results in 63 daily trips; with 10% (or 6) arriving during the AM peak hour.
- Step 13: Adding the employee and non-employee vehicle trips results in the total inbound or arriving trips.

Step 14: On the basis of other surveys, ITE or updated NCHRP 187 data, compute the % inbound/outbound peak hour trips. In this example, approximately 15% of the total trips are outbound. Since the total trips are not known at this point, a simple equation determines this volume.

$$\begin{aligned} X &= \text{Total (in and out) Trips} \\ 85 &= \text{Inbound Trips (from Step 13)} \\ 85 + .15X &= X \\ 85 &= X - .15X \\ 85 &= .85X \\ 100 &= X \\ 100 - 85 &= 15 \text{ outbound trips} \end{aligned}$$

Step 15: Adding the 85 inbound and 15 outbound trips results in the total AM trips.

Step 16 thru 21: A process similar to Steps 10-15 is used except the "departure" rate is reduced based on ITE, updated NCHRP 187 data or local surveys. In the example this is assumed to be 50% rather than the 55% AM arrival rate.

Step 22: Calculate the AM peak hour trip generation rate by dividing the 100 inbound and outbound AM peak hour trips generated by 62,000 square feet (Step 1) which results in 1.61 trips per 1000 gross square feet.

Step 23: Repeat the Step 22 calculations using 98 PM peak hour trips generated by 62,000 square feet (Step 1) which results in 1.58 trips per 1000 gross square feet.

This procedure for estimating office generated peak hour traffic is essential when TSM, transit or subway ridership is a significant factor. It also is a basis for modifying such factors over a 15 to 20 year period to reflect important changes in employee modes of travel. The effect of various factors on the trip rate is evident using sensitivity analyses.

TRIP DISTRIBUTION/ASSIGNMENT

Once the peak hour trips to be generated are estimated, it is necessary to determine the geographic distribution. For example, for residential uses, where will the residents work? For office uses, where will the employees live? This can be achieved by considering one of the following techniques.

1. Trip distributions based on previous studies, i.e. the percentage of generated site trips using each site approach corridor, as documented in previous studies for nearby sites.
2. Experienced judgment and knowledge of local conditions.
3. A combination of 1 and 2.
4. Using a special zip code analysis for a representative land use.
5. Item 4 plus a housing analysis if a 20-year study period will change the trip distribution pattern significantly.
6. Areawide travel model results including trip tables by trip purpose.
7. Gravity Model (Quick Response System or NCHRP 187)

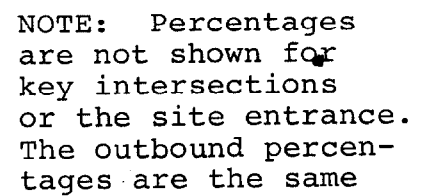
The trip distribution percentage is applied to the generated inbound (to) and outbound (from) development trips, and the results are assigned to the road network. The results for a geographic distribution of trips for a 62,000 square foot office building on a basic road network are shown on the top of Figure C-1 for the AM peak hour. The results of applying the percentages to the estimated total two-way trips and assigning them to the road network are shown at the bottom of Figure C-1. Note that if a road link is one way, the inbound and outbound assignments do not use the same links, so care must be taken to balance the network. Of course, turn restrictions and other elements can complicate the assignment process.

To illustrate how trip distributions may vary over a 15 to 20 year period in a complex site access study see Figure C-2. This shows the office trip distribution as a percent of the total trips on the three road networks, previously described in Figures 4a, 4b, and 4c in Chapter III.

Several items should be noted in reviewing Figure C-2.

- The example is for the 62,000 square foot office building to show how access routes change over time.
- Only inbound percentages have been indicated.
- The geographic distributions vary between short term and long term to represent a shift in housing opportunities for office building employees.
- The road networks vary between short, mid and long terms.

GEOGRAPHIC
DISTRIBUTION AS
A PERCENT OF
TOTAL INBOUND
TRIPS GENERATED

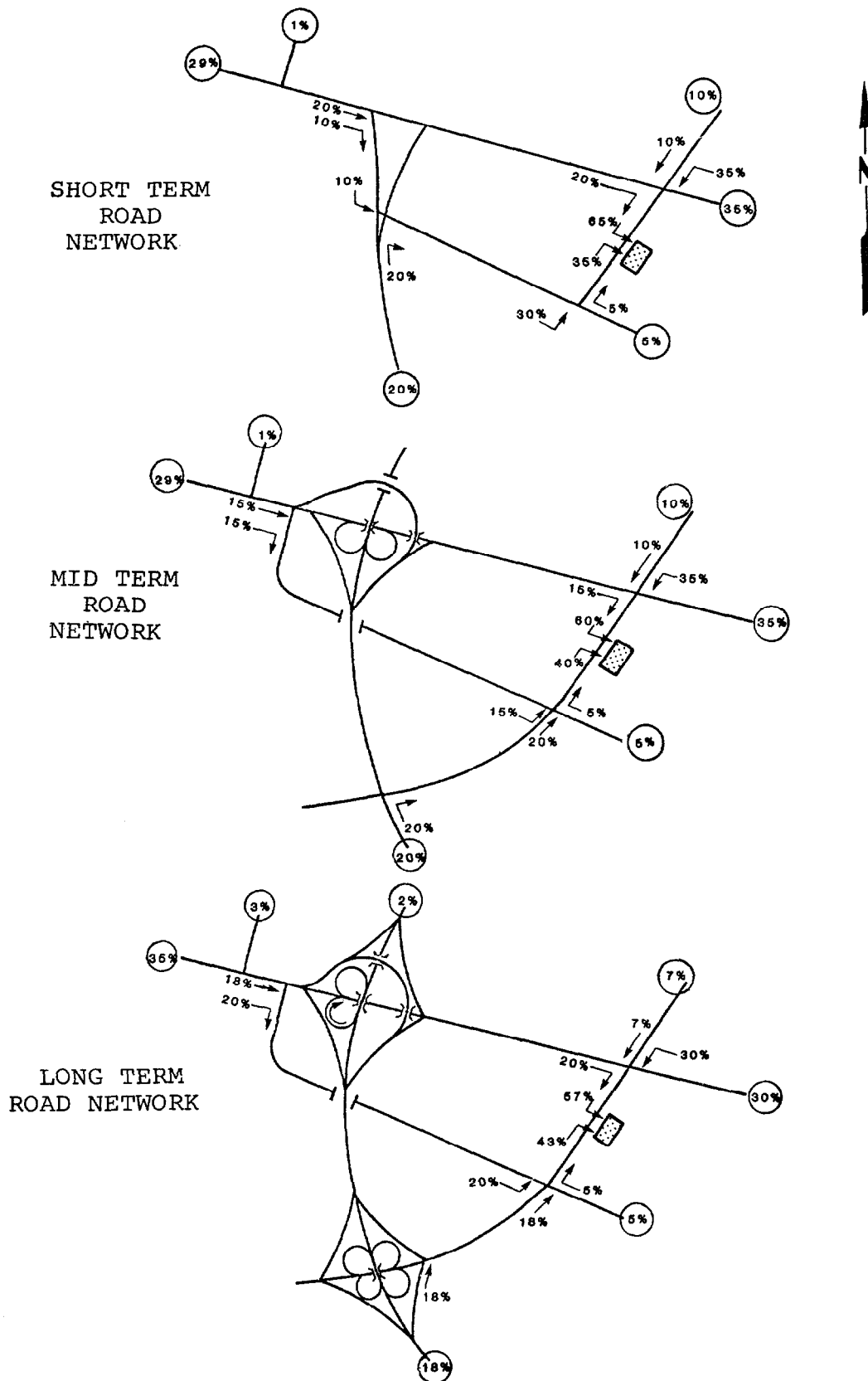


The diagram shows a central rectangular component with a hatched pattern. Above it are labels 'IN 85' and 'OUT 15'. Below the component is a label '54'. To the left of the component is a label '34'. To the right is a label '13'. Arrows indicate signal flow: an arrow labeled '5' points down into the top-left port; an arrow labeled '10' points down into the top-right port; an arrow labeled '15' points up from the bottom-left port; an arrow labeled '8' points up from the bottom-right port. Curved arrows show internal or external feedback loops, some labeled with numbers like '1', '2', '6', '9', '10', '13', '15', '31', '34', '54', '58', '59', '60', '61', '62', '63', '64', '65', '66', '67', '68', '69', '70', '71', '72', '73', '74', '75', '76', '77', '78', '79', '80', '81', '82', '83', '84', '85', '86', '87', '88', '89', '90', '91', '92', '93', '94', '95', '96', '97', '98', '99', '100'. Some arrows are labeled with circled numbers like (1), (2), (6), (9), (10), (13), (15), (31), (34), (54), (58), (59), (60), (61), (62), (63), (64), (65), (66), (67), (68), (69), (70), (71), (72), (73), (74), (75), (76), (77), (78), (79), (80), (81), (82), (83), (84), (85), (86), (87), (88), (89), (90), (91), (92), (93), (94), (95), (96), (97), (98), (99), (100).

⑧ In

⑧ Out

FIGURE C-2
 EXAMPLE OF GEOGRAPHIC DISTRIBUTION OF SITE GENERATED
 TRAFFIC, AS A PERCENT OF TOTAL INBOUND TRIPS GENERATED, FOR
 SHORT, MID TERM AND LONG TERM ROAD NETWORKS



- The "building" entrance inbound volumes vary from 65/35 in short term; to 60/40 in mid-term; to 57/43 in the long term.
- This process must be repeated for not only site trips, but other new development trips in a complex study.
- Following the percent distributions, generated traffic for all sites must be assigned to the road network.

This series of analyses results in site related peak hour traffic road network assignment(s) which are now sufficiently compatible for merging with Phase II results.

LEVELS OF SERVICE

The levels of service can be computed manually for basic site access studies. For complex studies, tabulations and level of service calculations can be performed using the computer with technical refinements tested manually against design options. Also unique solutions requiring considerable level of service experience will undoubtedly have to be evaluated. How the level of service calculations are performed are subject to local guidelines because there is some difference of opinion as to the merits of various techniques. Two techniques are usually acceptable:

- Highway Capacity Manual: Operation/Design
- Highway Capacity Manual: Planning Analysis

A combination of both methods is sometimes used. While the Operation/Design approach must be used if freeway ramps and weaving sections are involved; the Planning Analysis can be used for at-grade intersections. The Transportation Research Board (TRB) is in the process of releasing updated highway capacity manuals that conform to the new standards. Prior to this, the methods were found in the 1965 Highway Capacity Manual and TRB Circular 212.

The Operation/Design method uses six level of service categories, A thru F:

- Level of Service A: a condition of free flow with low traffic density, where no vehicle waits longer than one signal indication.
- Level of Service B: stable flow of traffic where only on a rare occasion do drivers wait through more than one signal indication.

- Level of Service C: still in the zone of stable flow, but intermittently drivers must wait through more than one signal indication and backups may develop behind left turning vehicles.
- Level of Service D: approaching instability; drivers restricted in their freedom to change lanes and delay approaching vehicles may be substantial during peak hour.
- Level of Service E: traffic volumes are near or at capacity on the arterial, and long queues of vehicles may create lengthy delays especially for left turning vehicles.
- Level of Service F: congested condition of forced traffic flow, where queued backups from locations downstream restrict or prevent movement of vehicles out of the approach, creating a storage area during part or all of the peak hour.

These six categories are used in most site access studies. Oftentimes Level of Service D is adopted by public agencies as the maximum Level of Service acceptable in an urban area and Level of Service C in a rural area. The six categories have provided an excellent basis for negotiations. The Planning Analysis method uses three descriptive categories: Below Capacity (level of service A, B, or C); Near Capacity (LOS D/E); and Above Capacity (LOS E/F).

The local/state ordinances and requirements should be used in calculating Level of Service. It is possible, as with the two current methods for calculating Level of Service, that some agencies will continue to require the guidelines considered most appropriate to their local or state situation.

APPENDIX D CASE STUDIES

Recognizing the need to show the application of trip generation rates and to test the sensitivity of levels of service to a variation in trip generation rates, trip distribution patterns and normal growth rates, four case studies were conducted. These case studies represent three of the more prominent land uses.

1. A mall site expansion in the suburbs of a small city
2. A mixed use project on the outskirts of a small town
3. A multi-tenant office park in a suburban area
4. A mixed use project containing hotel, offices, residential and retail uses in a suburban area.

The first case study is illustrated using the seven step site access study process. The other three case studies, although addressing all phases of the process, are formatted as follows:

- summary of technical issues
- level of service sensitivity tests
- level of service sensitivity results
- summary of findings

CASE STUDY NO. 1: OFFICE COMPLEX/MOTEL

Site Access Study Process

To illustrate how the basic site access study process, described in Chapter III, and summarized in Figure 2 applies, the various technical elements of each phase are described below for Case Study No. 1.

Phase I.- Establish Study Design and Verify Existing Peak Hour Traffic Situation

The site development program was first confirmed with the client to establish the proposed new land uses/density and build out year.

- Two new office buildings (total 100,000 gross sq. ft.)
- A 109 room motel
- All three facilities would be completed within two years on out parcels surrounding a small regional mall already in existence.
- Appropriate mall site plans were also obtained to understand the roadway and lane configuration. A site reconnaissance was also performed, and a meeting held with the site engineer and architect.

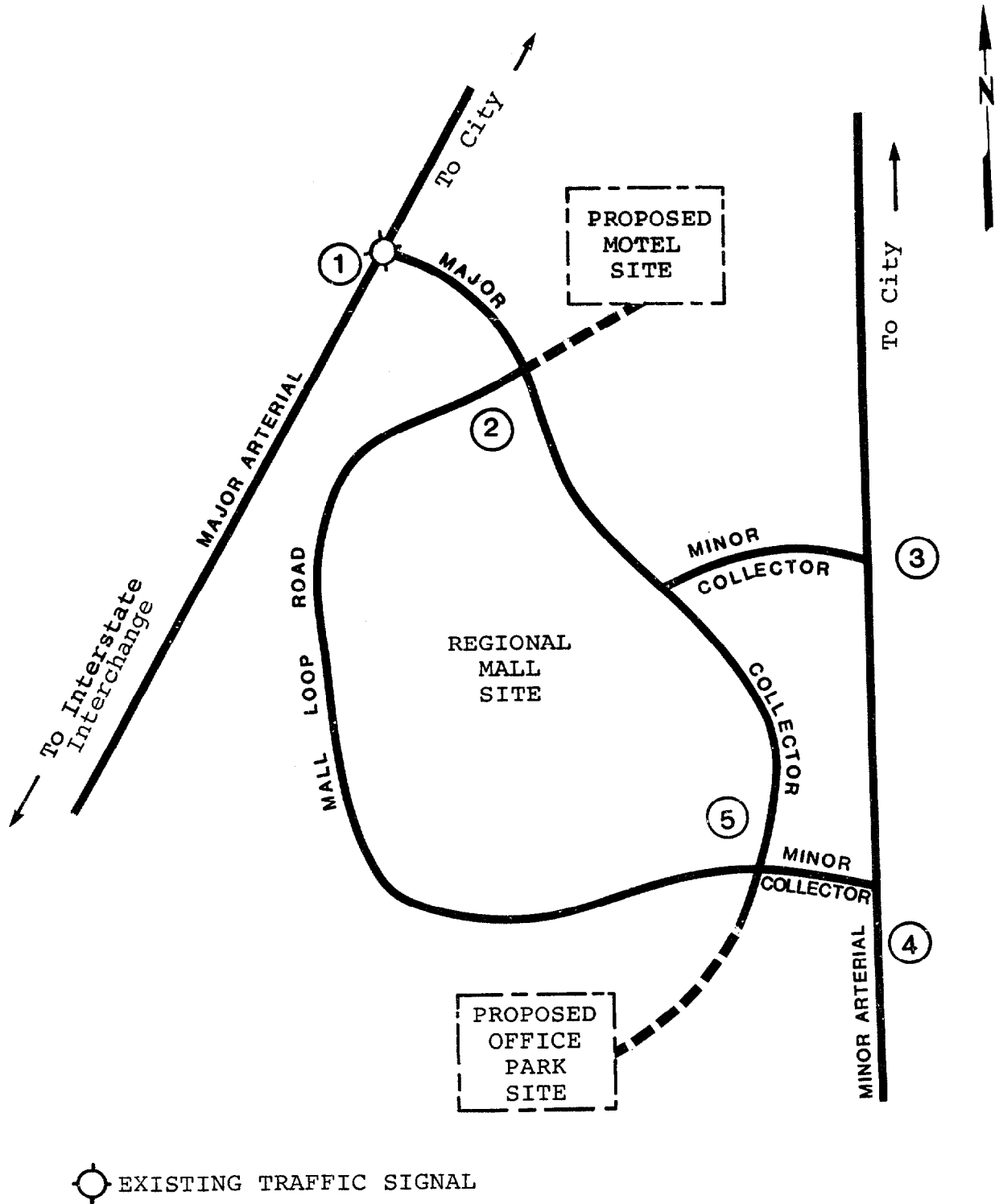
Since the mall already existed, the site access needs associated with the new office and motel uses were very closely related to the base peak hour mall traffic. Also, the study area was less complicated because it was principally within the confines of the mall property, and the uses could be built as-zoned. The issue with local (County and State) officials was simply, 1) would the new uses create significant peak hour impact; and 2) if the impact was significant, what roadway improvements, by the mall owner, on the mall roadway network or at key intersections, would be necessary to achieve acceptable peak hour traffic conditions after completion of the office buildings and the motel?

The key issue with the client was to select a representative situation to collect new peak hour mall and office traffic. Fortunately, the study began in the winter, so March was selected for an AM and PM peak hour traffic count at key intersections. November (Thanksgiving) through December (Christmas) counts were to be avoided, if possible, since these mall volumes do not represent design day conditions but are instead peak shopping (traffic) conditions. Since the new office would only generate traffic on weekdays, a Friday was selected for the mall traffic counts in March. While mall traffic would be higher on a Saturday, the office uses would not be significantly occupied. The motel was considered to generate an insignificant amount of peak hour traffic on a Saturday. Conversations with local (County and State) officials were minimal since the study area was so well defined; and re-zoning was not an issue. The review process for the technical traffic information was discussed; including buildout year, land uses/density, annual growth rates and other proposed development.

Five intersections were included for analysis (See Figure D-1).

- Intersection 1 - The main access to the mall site via a heavily traveled, four lane, undivided major arterial.
- Intersection 2 - The major point of convergence for mall traffic to and from the major arterial, as well as the sole access route to the motel site.
- Intersections 3 & 4 - Secondary access points to the mall site from the lightly traveled, four lane, undivided minor arterial.
- Intersection 5 - The sole access to the office park site at the end of a major collector street.

FIGURE D-1
CASE STUDY NO. 1
SITE LOCATION AND ROAD NETWORK



Peak period 7:00-9:00AM and 4:00-6:00PM turning movement counts were made at all key intersections on a Friday in March. Tabulations indicated peak hours to be 7:15-8:15AM and 4:30-5:30 PM. All locations operated at level of service A during both peak hours. TRB Circular 212 was used for the calculations. No adjustments were made in the March mall traffic since this month was considered to be representative of an average or typical month for malls, according to information from Urban Land Institute and Institute of Transportation Engineers. While no significant site access constraints were identified in this process, operations at intersections 1 and 2 were more carefully analyzed because the motel would create a new entrance at intersection 2, and possibly influence the efficiency of intersection 1.

Phase II. - Project Future Peak Hour Traffic Situation Without Site(s) Developed

This phase primarily involved the comparison of available data to establish annual growth rates. For example, the state highway department had a 12 hour Tuesday turning movement count for inter-section 1; exactly one year earlier (in March). A direct month to month weekday comparison was therefore possible to the new data obtained in Phase I. The annual increase in traffic was therefore substantiated. It was decided that 1984 major arterial through traffic would be increased +11% per year (or a total of +22%), to achieve 1986 traffic, which would reflect new growth beyond the subject site.

At the other four locations a +3% per year growth (or +6% total) was used. The 1984 volumes, except for mall volumes, were increased to 1986 AM and PM peak hour volumes and the levels of service calculated. Without the office and motel sites developed, all intersections would operate at level of service A during the AM peak hour. Intersection 1 would operate at level of service B during the PM peak hour with all other intersections operating at level of service A. The Highway Capacity Manual was used for the level of service calculations.

Phase III. - Project And Distribute Peak Hour Site Development Traffic

The following process was used to estimate the AM peak hour trips to be generated by new office and motel facilities.

	AM Two Way Trip Rate	Total Two Way Trips	% In	No. In	% Out	No. Out
Office: 100,000 Sq.Ft.	2.50/1,000SqFt	250	85	213	15	37
Motel: 109 Rooms	0.66/room	72	50	36	50	36

For the PM peak hour, the following process was used to estimate the PM peak hour trips to be generated by new office and rental facilities:

	PM Two Way <u>Trip Rate</u>	Total Two Way <u>Trips</u>	% <u>In</u>	No. <u>In</u>	% <u>Out</u>	No. <u>Out</u>
Office: 100,000 Sq. Ft.	2.82/1,000SqFt	282	14	40	86	242
Motel: 109 Rooms	0.59/Room	64	50	32	50	32

The motel was assumed to have no restaurant or meeting facilities. Trip rates were in conformance with ITE data and acceptable to local officials. [14] No reduction was taken for trips between the land uses within the site (internal trips).

The geographic distribution was based on familiarity with the local housing market and travel patterns and inputs from the County officials. The new trips were then assigned to the road network -- which was essentially unchanged from the 1984 network, although a fourth leg was added at both Locations 2 and 5.

Phase IV. - Project Future Peak Hour Traffic Situation with Site(s) Developed

Phase II and III results for the AM and PM peak hours were next combined to represent conditions with the office and motel sites occupied in 1986. The AM peak hour was again found to result in Level of Service A at all intersections; however, during the PM peak hour, Level of Service B occurred at both intersections 1 and 2.

Phase V. - Develop Site Access Related Solution

It was concluded that acceptable levels of operating efficiency

14. Trip Generation, An Informational Report, Institute of Transportation Engineers, Washington D.C., 1982

would be achieved in 1986 with the new facilities constructed and occupied. Existing roadway geometrics were considered to be sufficient for 1986 conditions. A solution which involved new roadway or traffic operational improvements considered necessary in conjunction with the new development, was not necessary -- except for the roadway and entranceway connections necessary to serve the office and motel sites.

LOS Sensitivity Tests

Because of the relatively straight-forward nature of the development proposal, this case study provides an excellent opportunity for testing the sensitivity of level of service variations for three fundamental components of a site access study: 1) trip generation rates, 2) the trip distribution pattern and 3) normal (traffic) growth rates. Four conditions were evaluated as described below and summarized on Table D-1:

- Condition 1: This is the "worst case" condition, involving high office and motel site trip generation rates; (Distribution A, Figure D-2) a geographic distribution with 75% of office site generated traffic passing through the most heavily traveled intersections (1 & 2); and high normal growth rates for both through traffic on adjacent arterials and (existing) mall site traffic. Distribution A reflects the current distribution of mall site traffic.
- Condition 2: This condition is the same as Condition 1 except that office and motel generated traffic rates have been reduced to those shown in updated NCHRP 187. [15]
- Condition 3: This condition uses the updated NCHRP 187 Table 1 trip generation rates, as in Condition 2, but the distribution of office site generated traffic, at intersections 1 & 2, has been reduced to 55% to reflect greater use of the minor arterial; see "B" Trip Distribution (Figure D-3).
- Condition 4: This condition is the same as Condition 1 except for reduced rates of normal growth for arterial through traffic and mall site traffic. The 2.7% annual growth rate for arterial through traffic was based on a long range, regional forecast of traffic on the major arterial performed by the state. The mall site traffic growth rate was also reduced to approximately one-half of Conditions 1, 2 and 3.

15. Development And Application Of Trip Generation Rates, Federal Highway Administration (HHP-22), January 1985

TABLE D-1
CASE STUDY NO. 1
ALTERNATIVE CONDITIONS EVALUATED

<u>CONDITION</u>	<u>Description</u>
1	ITE Rates
2	Updated NCHRP 187 Rates
3	Updated NCHRP 187 Rates + Modified Trip Distributions
4	Reduced Growth Rates

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
<u>TWO WAY</u>				
<u>SITE TRIP</u>				
<u>GENERATION RATES</u>				
OFFICE (trips per 1000 gross sq.ft.)				
AM peak hour	2.50	1.98	1.98	2.50
PM peak hour	2.82	1.93	1.93	2.82
MOTEL (trips per room)				
AM peak hour	.66	.52	.52	.66
PM peak hour	.59	.54	.54	.59
<u>SITE TRIP</u>				
<u>DISTRIBUTION</u>				
<u>PATTERN</u>				
	"A"	"A"	"B"	"A"
	See Figure	See Figure	See Figure	See Figure
	D-2	D-2	D-3	D-2
<u>ARTERIAL TRAFFIC</u>				
<u>NORMAL ANNUAL GROWTH</u>				
<u>RATE</u>				
AM peak hour	+11%	+11%	+11%	+2.7%
PM peak hour	+18%	+18%	+18%	+2.7%
<u>MALL SITE</u>				
<u>NORMAL ANNUAL GROWTH</u>				
<u>RATE</u>				
AM peak hour	+3%	+3%	+3%	+2%
PM peak hour	+10%	+10%	+10%	+5%

FIGURE D-2
CASE STUDY NO. 1
"A" TRIP DISTRIBUTION FOR
OFFICE AND MOTEL GENERATED TRIPS
(EXISTING SITUATION AND
CONDITIONS 1, 2, & 4)

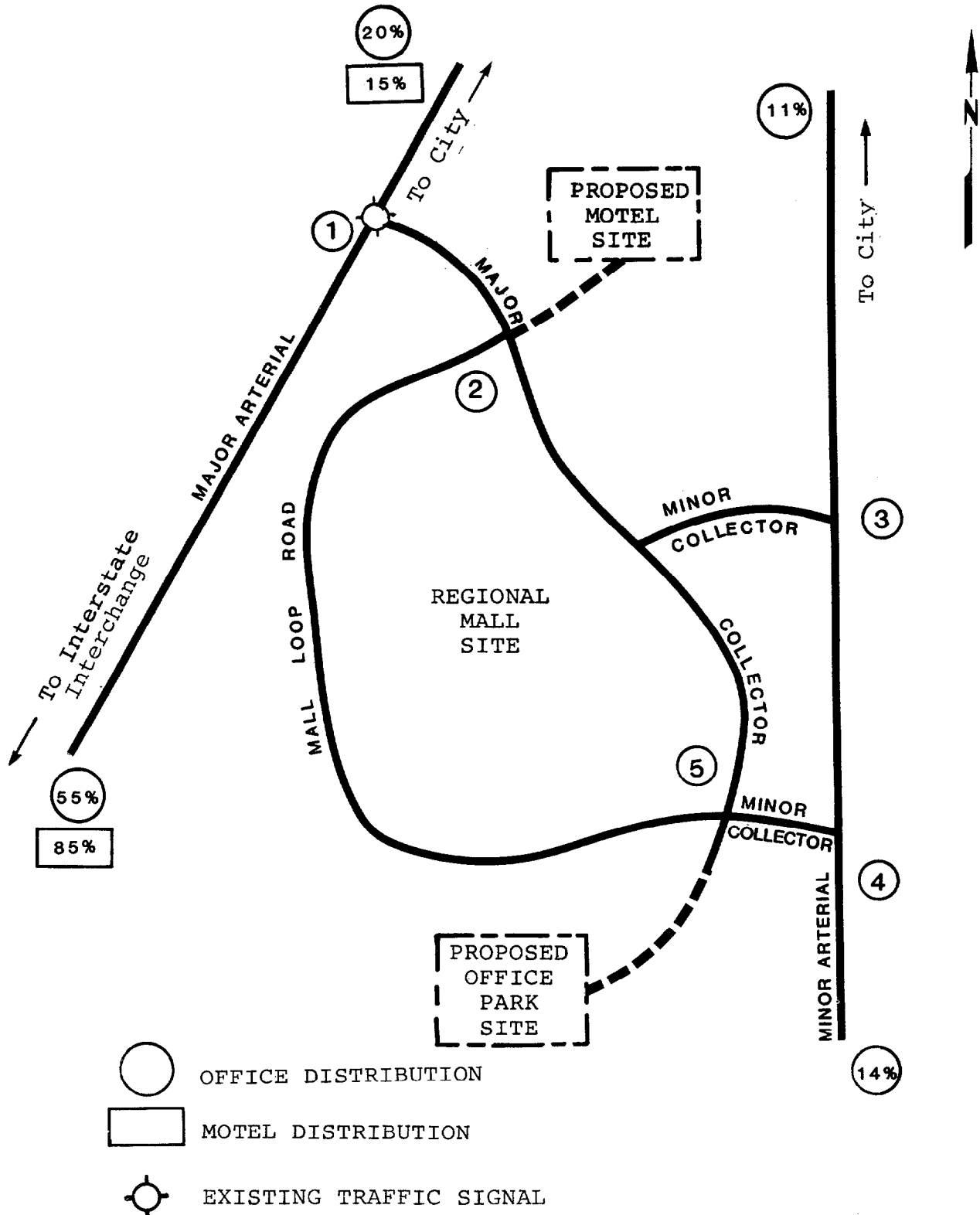
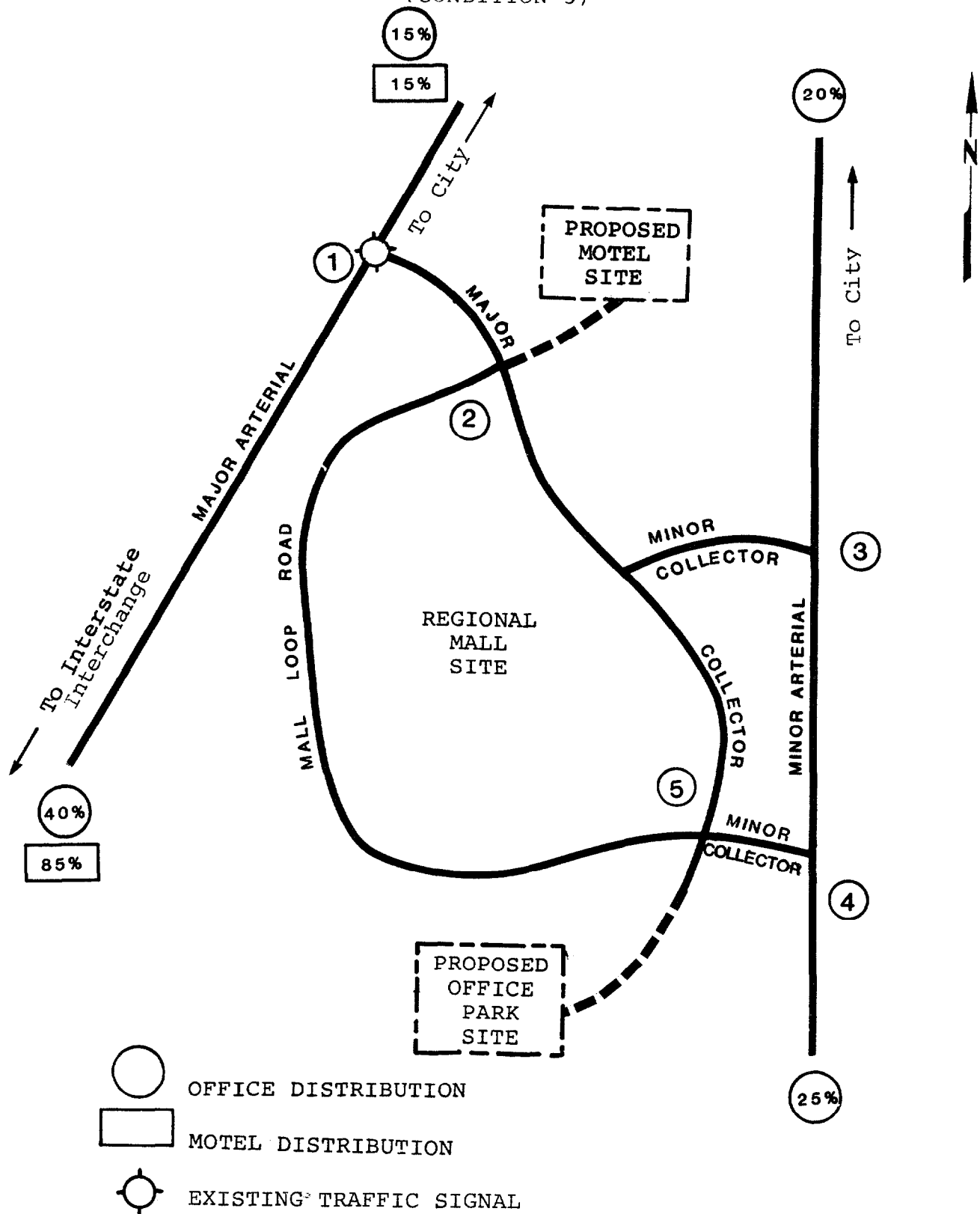


FIGURE D-3
CASE STUDY NO. 1
"B" TRIP DISTRIBUTION FOR
OFFICE AND MOTEL GENERATED TRIPS
(CONDITION 3)



LOS Sensitivity Results

Table D-2 shows the resulting levels of service and critical lane volumes for Conditions 1 through 4 at all five intersections. The only intersections that operate at a level of service worse than D are Intersections 1 and 2, and this occurs only during the PM peak hour. During the AM peak hour all Intersections operated at Level of Service A, regardless of the condition tested. During the PM peak hour at Intersection 1, the Condition 1 LOS F, is improved to an E, with the office and motel site traffic generation rates reduced by approximately 20% (Condition 2).

The Level of Service remains E, however, even though the office site traffic is re-assigned to the intersection after changing the distribution pattern from 75% to 55% (Condition 3). If the anticipated growth in arterial through traffic and mall site traffic is not achieved (Condition 4), a very much improved Level of Service C/D is produced, even with high site traffic generation rates and a high percentage of site traffic assigned to the inter- section.

For Intersection 2 : Condition 1, LOS E remains even after the office and motel site generated traffic is reduced by 25% (Condition 2). Reduction of the trip generation rate and trip distribution improves the Condition 1 Level of Service E to a D, (Condition 3). Approximately the same effect is achieved if the anticipated rate of growth in through and mall site traffic is not achieved (Condition 4).

Summary

A difference of 20% in the trip generation rate, combined with a 20% variation in the trip distribution pattern changes forecast intersection traffic sufficiently to effectuate a change of one level of service. However, variations in the normal growth rate revealed an even greater change in level of service results.

TABLE D-2
CASE STUDY NO. 1
PEAK HOUR LEVEL OF SERVICE COMPARISON FOR CONDITIONS 1, 2, 3, 4
LEVEL OF SERVICE AND CRITICAL LANE VOLUMES AT INTERSECTIONS 1-5

Condi- tion	Intersection									
	1		2		3		4		5	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
1	A 509	F 1447	A 508	E 1414	A 244	A 539	A 245	A 502	A 540	A 601
2	A 476	E 1377	A 467	E 1293	A 240	A 538	A 239	A 485	A 485	A 483
3	A 446	E 1322	A 371	D 1203	A 245	A 543	A 291	A 543	A 485	A 359
4	A 440	C/D 1138	A 540	D 1259	A 185	A 374	A 209	A 364	A 540	A 563
(PHASING)										
	3 PHASE		3 PHASE		2 PHASE		2 PHASE		2 PHASE	

LEVEL OF SERVICE CRITERIA
(Vehicles/Hour)

	3 PHASE	2 PHASE
LOS		
A	0 - 855	0 - 900
B	855 -1000	900 -1050
C	1000 -1140	1050 -1200
D	1140 -1275	1200 -1350
E	1275 -1425	1350 -1500
F	1425 -ABOVE	1500 -ABOVE

CASE STUDY NO. 2: MIXED USE PROJECT NEAR SMALL TOWN

Summary of Technical Issues

A mixed use project involving 757 apartments/condominiums, 214 single family attached dwelling units and 9.3 acres of light industrial/office space was proposed to be developed adjacent to a major arterial road near an Interstate highway (See Figure D-4). Key issues involving the project are described below:

- The residential development would have access to the major arterial solely via the minor collector shown on Figure D-4. The light industrial/office space would have access via the major collector and the minor collector. This access routing detail was a function of the site plan road network.
- At the time of the development proposal, roadway widening improvements at Intersection 1 were committed by the state and other developers. Improvements at Intersection 2 were also being proposed in conjunction with this development since a fourth leg was being added to the intersection.
- The geographic distribution of site traffic is shown on Figure D-5. Industrial (office) traffic was assigned to the major collector and residential traffic was assigned to the minor collector. The same distribution patterns were used based on technical judgment regarding employment and housing opportunities.
- Corridor growth in the area was creating a worsening traffic situation on the major arterial, particularly for the four year traffic forecast anticipated at full development of the site.

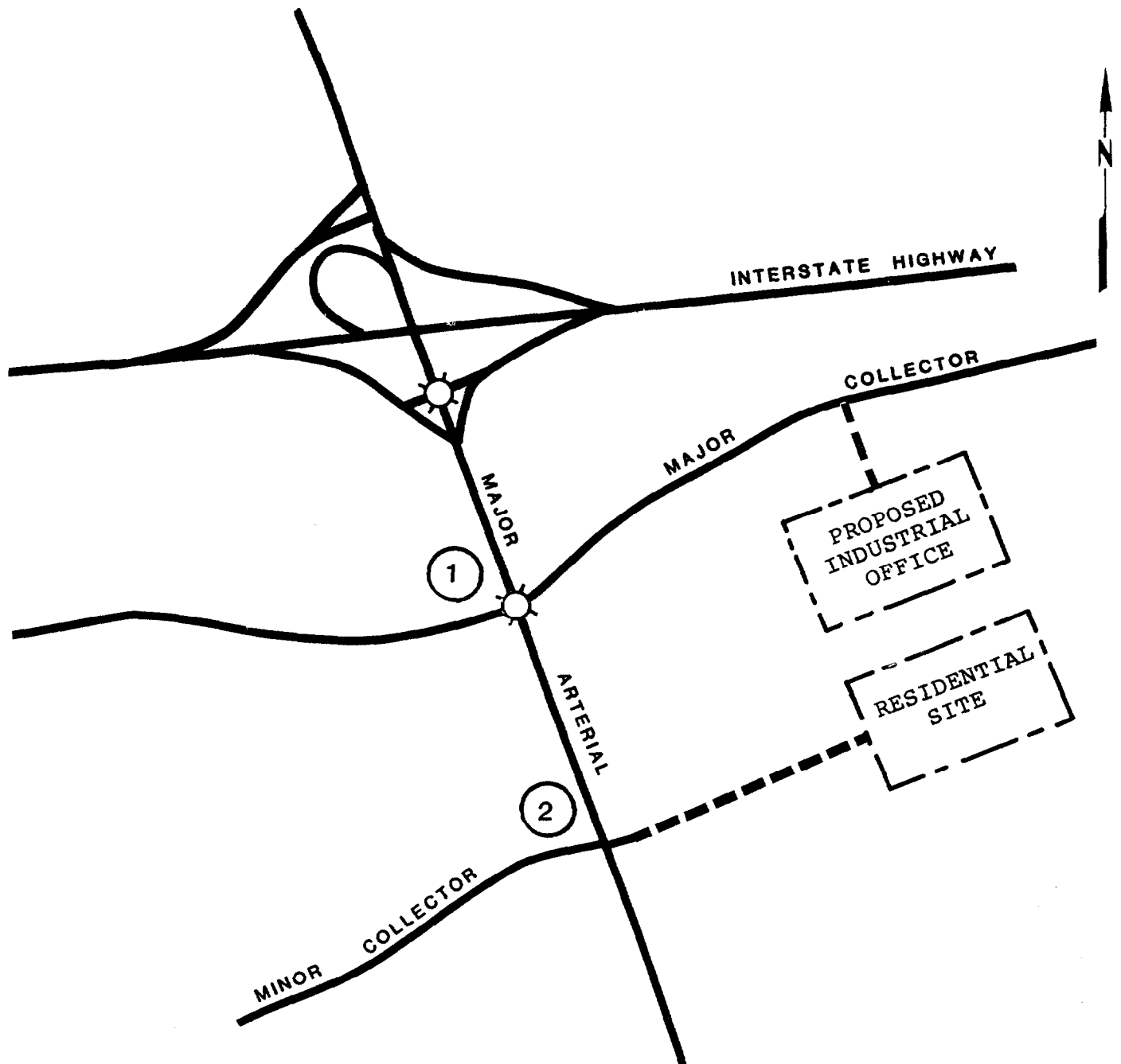
LOS Sensitivity Tests

In order to determine the effect of variations in trip generation rates on the two intersections, five alternative trip rate conditions were evaluated. Normal growth rates, road improvements, site traffic, and trip distribution patterns are the same for all five conditions.

These five conditions are described below and summarized in Table D-3:

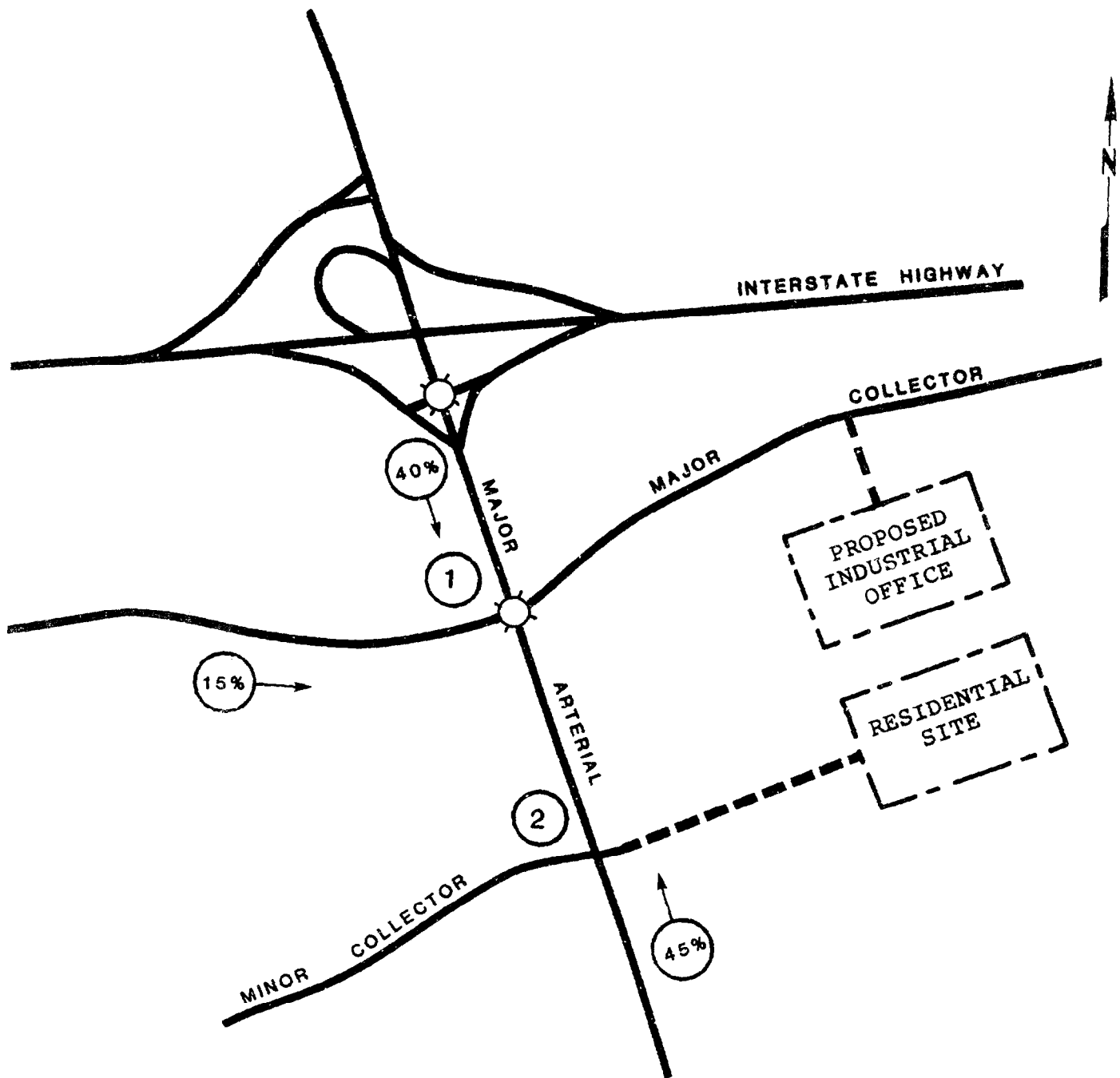
- Condition 1: The trip generation rates for both residential and industrial/office uses are the same as those used in the original site evaluation, and as accepted by the local jurisdiction. The original site evaluation used "per acre" trip rates for the light industrial development, and also stated a floor area ratio

FIGURE D-4
CASE STUDY NO. 2
SITE LOCATION WITH RESPECT
TO ROAD NETWORK



☉ EXISTING TRAFFIC SIGNAL

FIGURE D-5
CASE STUDY NO. 2
GEOGRAPHIC DISTRIBUTION OF SITE TRAFFIC



☉ EXISTING TRAFFIC SIGNAL

TABLE D-3a
CASE STUDY NO. 2
AM/PM PEAK HOUR TRIP GENERATION RATES BY LAND USE
FOR ALTERNATIVE CONDITIONS

<u>CONDITION</u>	<u>LAND USE</u>		
	Apartment / Condominium (per unit)	Single Family Attached (per unit)	Light Industrial Gross (per 1000 sq. feet)
1			
AM Trip Rate	0.44	0.56	0.65
PM Trip Rate	0.55	0.67	0.58
2			
AM Trip Rate	0.48	0.62	0.65
PM Trip Rate	0.61	0.74	0.58
3			
AM Trip Rate	0.40	0.50	0.65
PM Trip Rate	0.50	0.60	0.58
4			
AM Trip Rate	0.44	0.56	0.95
PM Trip Rate	0.55	0.67	0.88
5			
AM Trip Rate	0.55	0.44	0.95
PM Trip Rate	0.71	0.54	0.88

TABLE D-3b
CASE STUDY NO. 2
AM/PM PEAK HOUR COMPARISON OF TRAFFIC
GENERATED FOR ALTERNATIVE CONDITIONS

<u>CONDITION</u>	<u>GENERATED SITE TRAFFIC</u>			
	TOTAL TRAFFIC	PEAK HOUR RETAINED ON SITE	PEAK HOUR EXTERNAL (OFF SITE)	% CHANGE OFF SITE FROM CONDITION 1
1				
AM Trips	559	0	559	n.a.
PM Trips	653	0	653	n.a.
2				
AM Trips	605	0	605	8.0%
PM Trips	709	0	709	9.0%
3				
AM Trips	513	0	513	-8.0%
PM Trips	597	0	597	-9.0%
4				
AM Trips	607	0	607	9.0%
PM Trips	702	0	702	8.0%
5				
AM Trips	664	78	508	-9.0%
PM Trips	787	72	653	0.0%

of 0.4. The "per acre" rates have been converted to "per 1,000 gross square foot" rates based on the stated floor area ratio.

- Condition 2: The residential trip generation rates were increased 10% over Condition 1 rates. The light industrial trip generation rates are the same as those used in Condition 1.
- Condition 3: The residential trip generation rates were decreased 10% below Condition 1 rates. The light industrial trip generation rates are the same as those used in Condition 1.
- Condition 4: The residential trip generation rates are the same as those used in Condition 1. The light industrial trip generation rates were obtained from updated NCHRP 187. The light industrial office trip rates are approximately 50% higher than those used in Conditions 1, 2 and 3.
- Condition 5: Both residential and light industrial trip generation rates were obtained from updated NCHRP 187. Also note that external site traffic was reduced to account for work trips between the residential and light industrial components of this proposed development. The basis for determining traffic retained on-site is shown in Table D-4, and is based on factors presented in Table 6 of "Development and Application of Trip Generation Rates," prepared for Federal Highway Administration in January 1985. The reduction from total traffic generated to net external traffic was based on the internal traffic estimate for industrial use, because the internal traffic estimate for residential use is nearly equal to or exceeds the total traffic generated for the industrial use in all cases.

LOS Sensitivity Results

Table D-5 shows the resulting levels of service and critical lane volumes for Conditions 1 through 5 at Intersections 1 and 2. During the AM peak hour both Intersections 1 and 2 operate at acceptable Levels of Service (B or B/C and A, respectively) under all five conditions. The only variation based on different conditions occurs at Intersection 1, where the higher traffic generated under Conditions 2 and 4 results in a slightly reduced level of service.

During the PM peak hour, Intersection 2 would operate at a minimally acceptable Level of Service D under all conditions despite a substantial variation in PM peak hour external site traffic (see Table D-4). Intersection 1 operates at a Level of Service E under all Conditions except Condition 3, which

TABLE D-4
CASE STUDY NO. 2
CONDITION 5: INTERNAL/EXTERNAL TRAFFIC

PEAK HOUR VEHICULAR TRIPS GENERATED

		AM		PM	
		<u>IN</u>	<u>OUT</u>	<u>IN</u>	<u>OUT</u>
757 APARTMENT UNITS		68	348	371	167
214 SINGLE FAMILY ATTACHED UNITS		15	79	77	39
TOTAL RESIDENTIAL UNITS		83	427	448	206
162,000 GROSS SF LIGHT INDUSTRIAL		133	21	31	112

INTERNAL (ON-SITE) TRAFFIC ESTIMATE [1]

RESIDENTIAL	(55%)	(25%)	(40%)	(50%)
	46	107	179	103
INDUSTRIAL	(50%)	(80%)	(80%)	(50%)
	67	11	16	56

INTERNAL (ON-SITE) TRAFFIC ADJUSTED FOR DENSITIES [2]

RESIDENTIAL	11	67	56	16
INDUSTRIAL	67	11	16	56

NET EXTERNAL (OFF-SITE) TRAFFIC

RESIDENTIAL	72	360	392	190
INDUSTRIAL	66	10	15	56

[1] Table 6 , Development and Application of Trip Generation Rates, FHWA, January 1985

[2] Since there are only two land uses, the inbound internal trips to the residential area are outbound internal trips from the industrial area, and vice-versa.

TABLE D-5
CASE STUDY NO. 2
PEAK HOUR LEVEL OF SERVICE FOR CONDITION 1
Level of Service and Critical Lane Volume Summation
Intersection

Condition	1		2	
	AM	PM	AM	PM
1	B 986	E 1287	A 741	D 1218
2	B/C 991	E 1298	A 727	D 1222
3	B 981	D/E 1277	A 757	D 1214
4	B/C 1010	E 1287	A 750	D 1230
5	B 971	E 1289	A 730	D 1217
(PHASING)				
	3 PHASE		3 PHASE	

LEVEL OF SERVICE CRITERIA
(Vehicles/Hour)

3 PHASE

LOS

A	0 -	855
B	855 -	1000
C	1000 -	1140
D	1140 -	1275
E	1275 -	1425
F	1425 -	ABOVE

involves the lowest level of external site traffic. Under Condition 3, Intersection 1 operates at a D/E Level of Service.

Summary

This case study indicated that a variation in external trip generation rates by plus or minus eight or nine percent did not have a very significant effect on the resulting peak hour levels of service. In instances where the critical lane volume is within fifteen or twenty vehicles of a level of service limit, there is an indication that an eight or nine percent variation in trip rates will cause a level of service change of only one-half level.

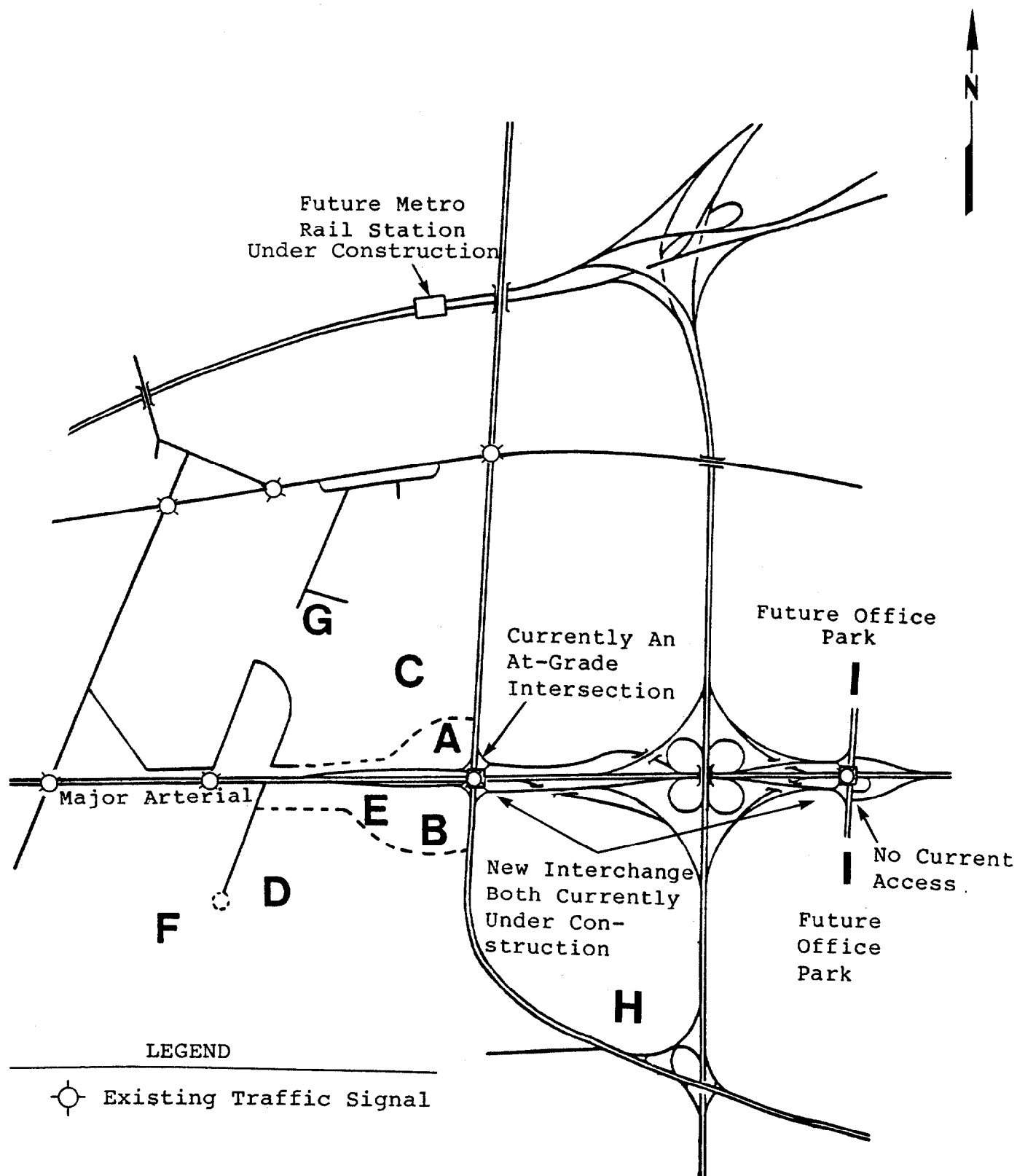
CASE STUDY NO. 3: OFFICE MULTI-TENANT

Summary of Technical Issues

Two major corporations combined development efforts to re-zone two corner tracts of land (tracts A and B) at a major at-grade intersection west of a major Interstate (freeway) interchange. Several issues made the situation extremely complex as illustrated in Figure D-6 and described below:

- To the east of the Interstate interchange, a very major re-zoning had been recently approved to permit a major office park and hotel complex to be constructed. As a condition of this re-zoning, the developers agreed to construct a new interchange as an extension of the Interstate interchange. A major ridesharing program was also proffered to reduce PM peak hour traffic and to allow the "extended" interchange to operate at LOS D in PM peak hours. This proffer was unusual since this tract was termed almost inaccessible prior to re-zoning.
- The state highway department was committed to construct a second interchange to replace the (existing) major at-grade intersection west of the Interstate interchange. This reconstruction would occur next to the tracts subject to re-zoning with construction impacting the site plans. The interchange would be identical in concept to the "extended" interchange except public funds would be used rather than private funds.
- Both interchanges are currently under construction.
- Besides the two subject sites A & B, there were two adjacent tracts C and D which could potentially be re-zoned as office parks, so it was agreed with the local reviewing agency that all four tracts would be included in the site access analysis. Re-zoning, however, only applied to tracts A and B.

FIGURE D-6
 LOCATION OF CASE STUDY NO. 3
 SITE WITH RESPECT TO AREA ROAD NETWORK



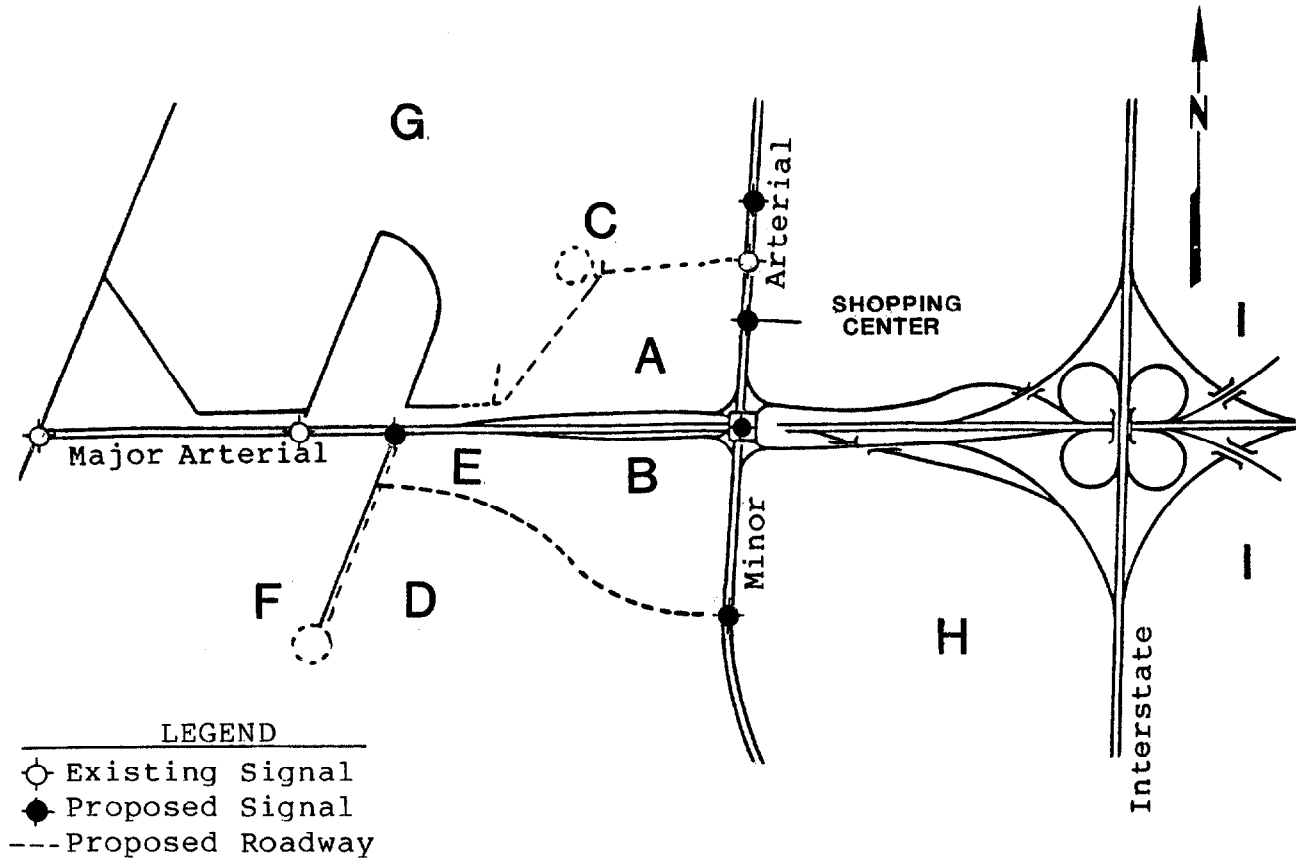
- Re-development of tracts A and B was further complicated due to the fact that each tract involved an on-site road. The fact that both roads were to be completed as part of each tract's development and then turned over to public agencies for maintenance, significantly influenced circulation patterns - as well as the trip distribution patterns for trips generated by all six tracts; A, B, C, D, E and F.
- Five other tracts were considered in the analysis for potential development: E, F, G, H and I.
- Site C is currently a public school but may be available for re-development, as presumed in this study.

A summary of the tracts by land use type and Floor Area Ratio (FAR) is indicated in Figure D-7; as agreed to with local review officials.

Additional technical information is summarized below:

- 1987 was considered to be the build out year for all new developments.
- AM/PM peak hour trip generation rates of 1.39/1.27 (as developed used the Table C-1 office trip generation rate technique) were used for tracts A, B, C and D. The process for establishing these rates is shown in Table D-6. Note the corporate office space criteria of 325 square feet per employee.
- Slightly higher trip rates were used for other new developments. The mode split of 13% bus and Metro/feeder bus was determined based on past experience with nearby development and agreement with local officials. By 1987, Metro rail service will be available to the subject tracts via a Metro rail station approximately 1 mile to the north along the minor arterial highway (see Figure D-6).
- The general geographic distribution is illustrated in Figure D-8. It should be noted that site generated traffic for each tract was assigned separately, and with the truck related connector roads there were significant modifications. The trip distribution patterns were based on basic patterns used in previous nearby studies and agreed to by local officials.
- The improved 1987 road network is illustrated in Figure D-9, along with intersection numbers for LOS reference. Note that the new state highway department interchange will be completed by 1987, significantly improving an existing LOS F. Also note the on-site public roads would be completed connecting tracts A and C, and B and D. The five signals along the minor arterial would all operate as in an interconnected system.

FIGURE D-7
CASE STUDY NO. 3
NEW DEVELOPMENT ANTICIPATED BY 1987

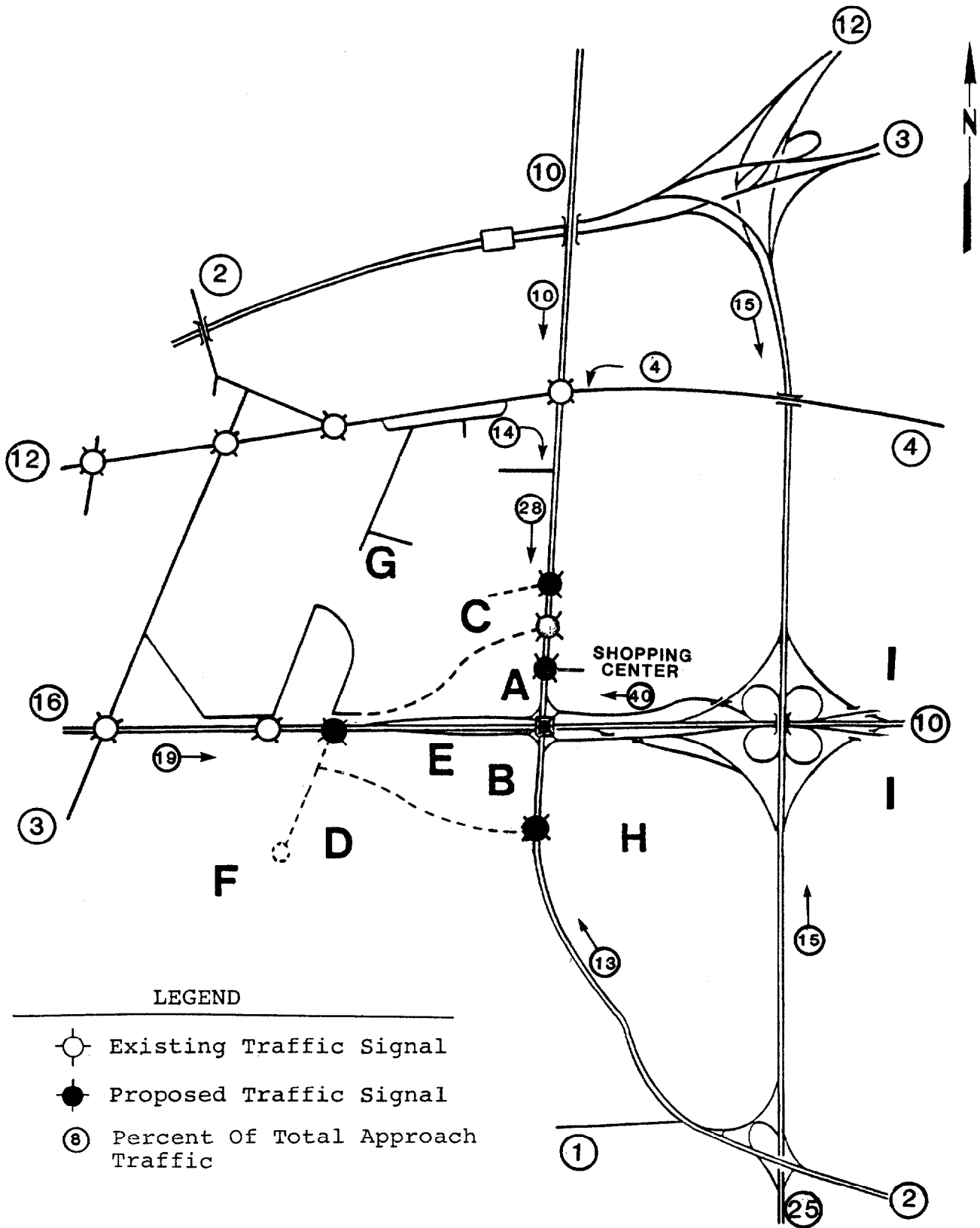


<u>DEVELOPMENT TRACT</u>	<u>LAND USE</u>	<u>FLOOR AREA RATIO</u>	<u>DENSITY</u>
A	Office	0.75	366,359 Gross Square Feet
B	Office	0.75	691,623 Gross Square Feet
C	Office	0.75	720,000 Gross Square Feet
D	Office	0.70	337,500 Gross Square Feet
E	Office	1.00	125,000 Gross Square Feet
F	Townhouse Office	N/A	45,000 Gross Square Feet
G	Industrial	(27.77 acre)	375,000 Gross Square Feet
H	Office	N/A	Additional 45,000 Gross Square Feet
I	Office	N/A	As Zoned

TABLE D-6
CASE STUDY NO. 3
SITE GENERATED AM/PM PEAK HOUR VOLUMES

OPTION ->	"A"	"B"	"C"	"D"
* GROSS FLOOR AREA (SQ. FT.)	377359	691623	337500	720000
* SQ. FT. / EMPLOYEE	325	325	325	325
* TOTAL EMPLOYEES	1161	2128	1038	2215
* MODE OF ARRIVAL	PERCENT	PERSONS	PERSONS	PERSONS
Bus	8.0%	93	170	83
Metrorail/Feeder Bus	5.0%	58	106	52
Walk/Other	0.5%	6	11	5
Vanpool	3.0%	35	64	31
Auto	83.5%	970	1777	867
total	100.0%	1161	2128	1038
* AVERAGE DAY EMPLOYEES (10% absentees)				
Vanpool		31	57	28
Auto		873	1599	780
total		904	1657	808
* VEHICLE TRIP ESTIMATES	Occupancy	Vehicles	Vehicles	Vehicles
Vanpool	10.00	3	6	3
Auto	1.30	671	1230	600
total	674	1236	603	1287
* OVERALL OCCUPANCY RATE		1.34	1.34	1.34
* AM PEAK HOUR	Arrival Rate=	66.00%		
	Vehicles	Vehicles	Vehicles	Vehicles
Total Inbound Trips	445	816	398	849
Total Outbound Trips	79	144	70	150
AM Peak Hour 2-way Trips	524	960	468	999
* PM PEAK HOUR	Departure Rate=	60.00%		
	Vehicles	Vehicles	Vehicles	Vehicles
Total Outbound Trips	405	742	362	772
Total Inbound Trips	71	131	64	136
PM Peak Hour 2-way Trips	476	872	426	908
* TRIP RATE / 1000 SQ. FT. (2-WAY)				
AM Peak Hour	1.39	1.39	1.39	1.39
PM Peak Hour	1.26	1.26	1.26	1.26

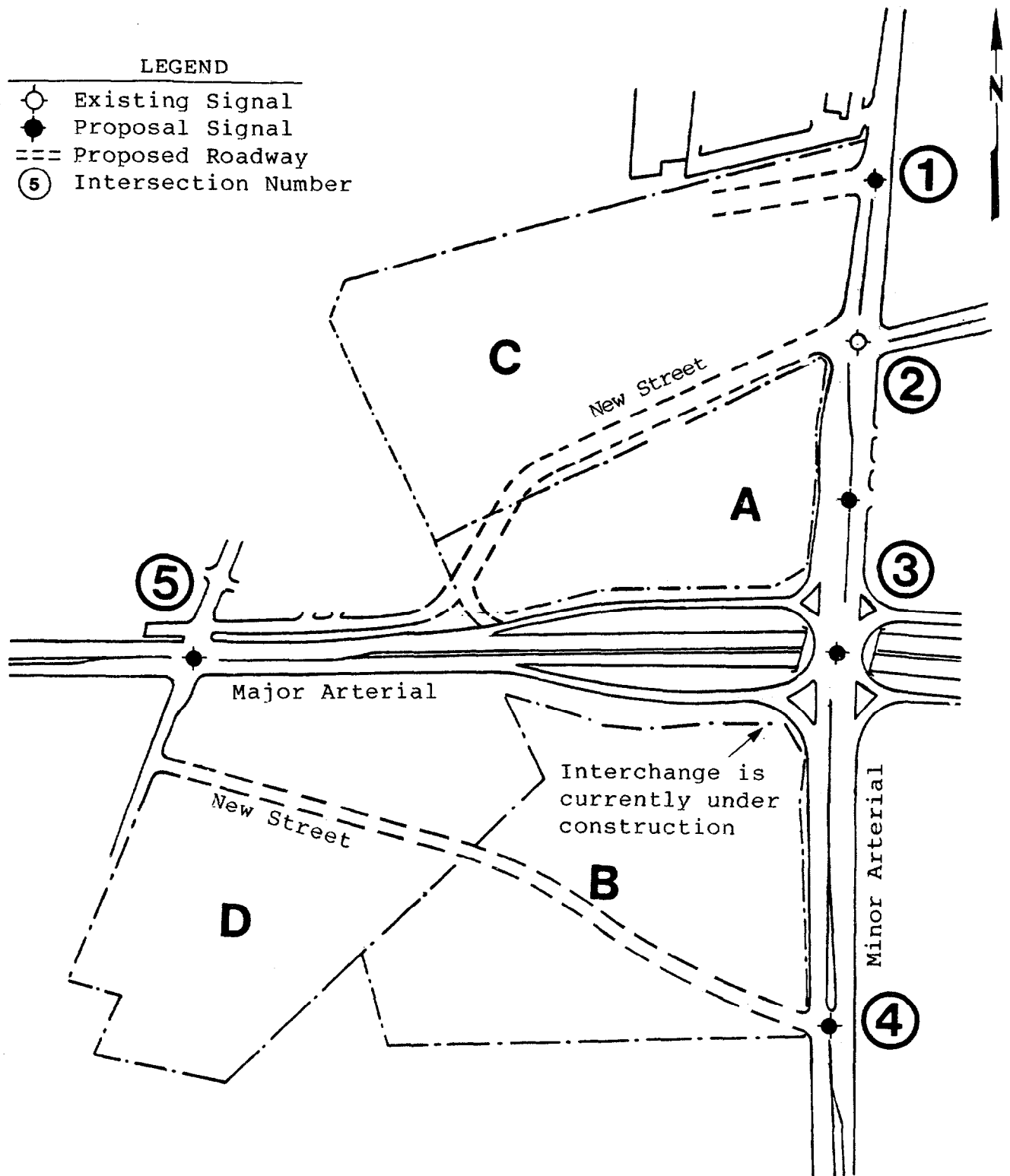
FIGURE D-8
CASE STUDY NO. 3
GENERAL GEOGRAPHIC
DISTRIBUTION



LEGEND

- ⊕ Existing Traffic Signal
- Proposed Traffic Signal
- ⑧ Percent Of Total Approach Traffic

FIGURE D-9
CASE STUDY NO. 3
1987 ROAD NETWORK



Level of Service Sensitivity Results

In order to determine the effect a change in the 1.39/1.27 (AM/PM peak hour) trip rates would have on the level of service at the five key intersections, the trip rates for tracts A, B, C and D were changed to 2.32/2.20, and 1.98/1.93 based on ITE and updated NCHRP rates, respectively. All other factors in the original analysis were left unchanged. This included the proposed road network. The technique for calculating level of service at the five interconnected signals was particularly complex because originally the proposed highway department phasing (without re-zoning and other new developments) had to be modified to account for the re-zoned density and the other new development. The modified phasing and level of service with the increased peak hour trips was based on the road network shown in Figure D-9. The results are shown in Table D-7 for four conditions.

Summary

The level of service results indicate that the trip rates used in the negotiations (1.39/1.27), along with all the other technical factors, roadway geometrics and operational features, achieved LOS D or better at all five locations. The LOS D or better is a re-zoning criteria in the County where this study was performed. This allowed a density of more than 2,000,000 gross square feet of new development to be built at the four tracts:

		TOTAL SQ.FT.
Tract A: 377,359	Tract C: 720,000	
Tract B: <u>691,623</u>	Tract D: <u>337,500</u>	2,126,482
1,068,982 Sq.Ft.	1,057,000 Sq.Ft.	

With the 1.39/1.27 rates replaced by the ITE rates of 2.32/2.20, two key intersections become significantly more congested with LOS E's at locations 1 and 5. The intersection 1 level of service calculations are very sensitive to any increase in "through" volumes along the minor arterial corridor so when the trip rate was changed to the ITE rate, the Condition 1 LOS C/C (AM/PM) deteriorated to a LOS E/D. Increased trips generated by tracts D and B, becoming through trips at intersection 1, were a reason for this increased congestion. The intersection 5 situation was impacted by increased traffic from all four tracts. These levels of service would have made the requested densities unacceptable and may have led to either density reductions, a change in land use mix or possibly a policy to have the developer agree to TSM actions to reduce peak hour

TABLE D-7
CASE STUDY NO. 3
PEAK HOUR LEVEL OF SERVICE COMPARISON FOR CONDITIONS 1 THRU 4

Condi- tion	Intersection									
	1 AM	1 PM	2 AM	2 PM	3 AM	3 PM	4 AM	4 PM	5 AM	5 PM
1	C 1032	C 1012	B 915	A 797	C 1046	B 1072	A 829	A 826	C 1028	D 1155
2	E 1289	D 1186	C/D 1142	B 994	C 1106	E 1317	C 1103	C 1106	E 1294	E 1313
3	D 1221	C 1118	C 1049	B 914	C 1074	D 1230	C 1046	B/C 993	E 1271	E 1246
4	D 1197	C 1123	C 1101	B 957	C 1031	D 1249	B 921	B 874	D 1195	D/E 1222
(PHASING)										
	3 PHASE		3 PHASE		3 PHASE		3 PHASE		4 PHASE	

CONDITION DESCRIPTIONS

Condition	Trip Rates		Comment
	AM	PM	
1	1.39	1.27	Office Trip Rate Technique (Table D-6)
2	2.32	2.20	ITE rates
3	1.98	1.93	NCHRP 187 (updated)
4	2.32	2.20	ITE / Reverse Analysis LOS D / Density Reduced

LEVEL OF SERVICE CRITERIA (Vehicles/Hour)

		3 PHASE	4 PHASE
LOS	A	0 - 855	0 - 825
LOS	B	855 - 1000	825 - 965
LOS	C	1000 - 1140	965 - 1100
LOS	D	1140 - 1275	1100 - 1225
LOS	E	1275 - 1425	1225 - 1375
LOS	F	1425 - ABOVE	1375 - ABOVE

trips and hence improve the level of service to a LOS D. Note that tract C was a County school, subject to possible rezoning at a future date. Using the updated NCHRP 187 trip rates (1.98/1.93) revealed the fact that intersection 1 achieved acceptable LOS D/C, but intersection 5 is almost as congested as with the ITE rates (E/E). To determine the impact of the decision to use the ITE trip rates versus the local 1.39/1.27 trip rates, the level of service was set at the maximum LOS D and solved for the maximum on-site density considering that both intersections 1 and 5 must operate at maximum LOS D. These levels of service results, indicated at the bottom of Table D-7, are obviously LOS D or better. However, to achieve this improved level of operating efficiency, a reduction in density of approximately 18% was required.

Density Reduction Necessary To Achieve LOS D <u>At Locations 1 and 5</u>		<u>Remaining Density</u>
Tract A	0	377,359 Sq. Ft.
B	190,000 Sq. Ft.	501,623 Sq. Ft.
C	75,000 Sq. Ft.	645,000 Sq. Ft.
D	115,000 Sq. Ft.	<u>222,500 Sq. Ft.</u>

TOTAL 1,746,482 Sq. Ft.

For tract B the 190,000 square feet represents a reduction of nearly 28% from the original density of 691,623, whereas tract A required no reduction. Of course to achieve LOS D, various mixed use options may have resulted in acceptable peak hour trips; however, mixed use may not have been marketable at this location or be a desired land use by local officials. Another alternative to retain this density, would be to have the developer agree to institute TSM actions.

Finally, it should be noted that in actual fact after the rezoning for tracts A and B was approved, tract D was re-zoned as an office park. However, to receive approval the developer agreed to monitor trips generated at certain stages of the development and if the trip rate exceeded the 1.39/1.27 rates, TSM measures would be instituted. There was no cut off in density or any other rigid control after a specific number of peak hour trips was reached. This case study indicates that trip rate variation alone can have very significant financial/land use/level of service implications in the site access study process.

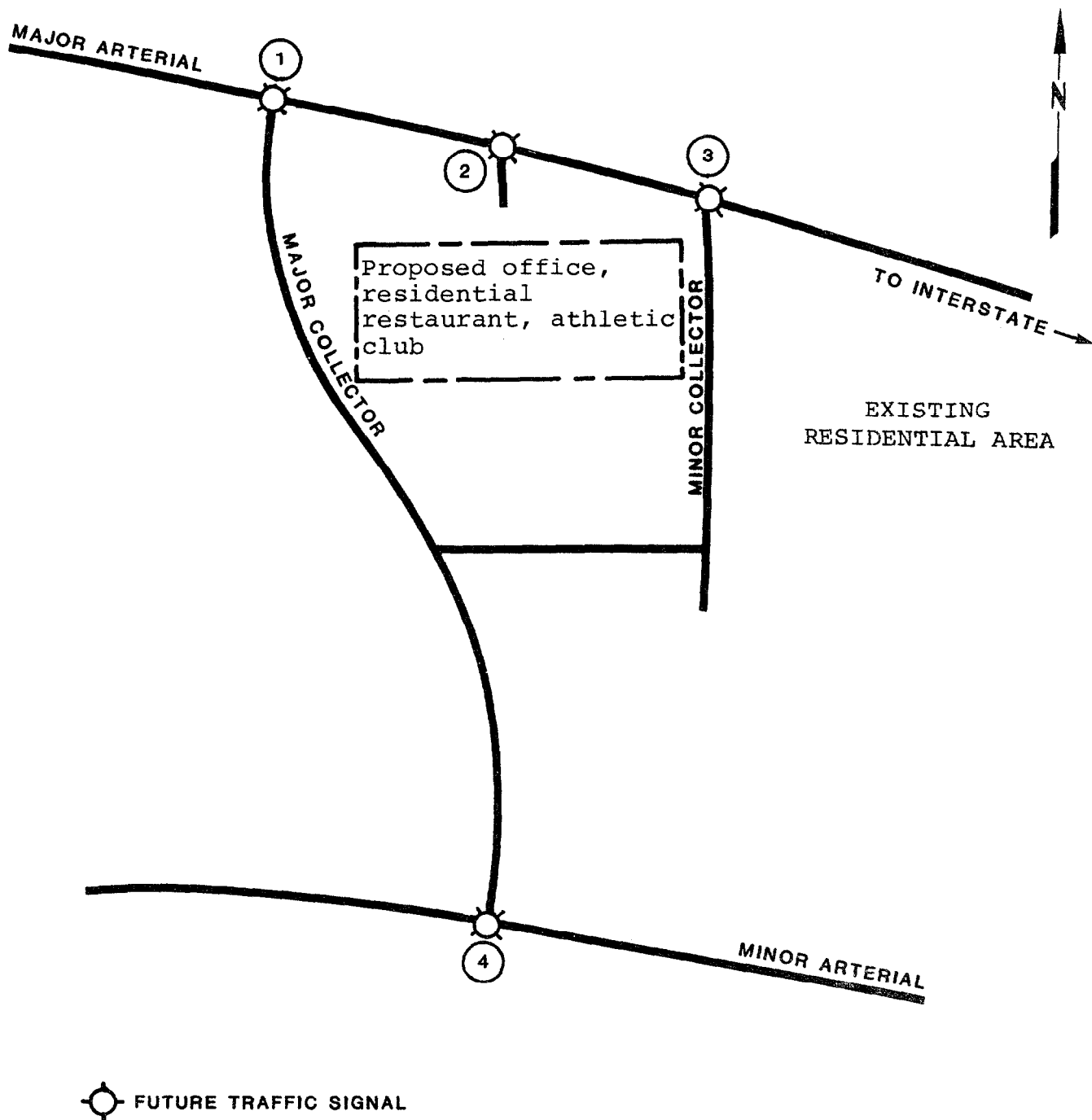
CASE STUDY NO. 4: MIXED USE PROJECT IN URBAN AREA

Summary of Technical Issues

The subject site is located along a major arterial highway, as illustrated in Figure D-10, near an Interstate interchange and in an urban setting. Pertinent site characteristics were:

- The tract was zoned for office, hotel, commercial and residential use. It was proposed, however, that the hotel be eliminated, retail space reduced, and office space increased.
- Local officials requested a complete site access study to verify changes in peak hour traffic conditions or roadway improvements associated with the proposed changes.
- Proposed site development for the build-out year 1990 included the following:
 - + Residential
 - High Rise Apartments - 882 units
 - Townhouses - 8 units
 - Total 890 units
 - + Office 1,027,617 square feet
 - + Restaurant 800 seats
 - + Sporting (Athletic) Club 46,088 square feet
- The major arterial highway is currently a four lane divided facility but it will be widened to a six lane divided facility by 1990; with three interconnected traffic signals. Public funds will be used for these improvements.
- The minor arterial roadway is currently a four lane divided roadway and would remain unchanged.
- A major collector road would be constructed as a four lane divided road by the developer of the subject tract and the developer of the tract immediately to the south. The collector - minor arterial intersection would be signalized.
- Other new office development (by 1990) traffic, for the tract south of the subject tract was also considered in the traffic analyses because of the shared use of the new collector road and intersections.
- The subject site, when completed should be accessed via five entranceways and a major parking garage.

FIGURE D-10
CASE STUDY NO. 4
SITE LOCATION AND ROAD NETWORK



- Local and regional bus service, including access to a Metro rail station, is available via the major arterial highway.
- The technical procedure used was similar to the complex site access study guidelines described earlier in this report; with the office trip generation rate technique used for estimating peak hour office generated traffic. ITE trip rates were used for the other land uses.

LOS Sensitivity Tests

Since the variables tested in this case study relate only to the office trip generation technique, it is necessary to explain how a change in each variable resulted in a slightly different AM/PM peak hour trip rate. This is best illustrated by considering Tables D-8 through D-14; which represent Conditions A through G.

The 2-way trip rates per 1000 sq.ft. of gross office space are shown below:

	<u>AM Peak Hour</u>	<u>PM Peak Hour</u>
CONDITION A	1.56	1.46
CONDITION B	1.71	1.59
CONDITION C	1.38	1.29
CONDITION D	1.76	1.64
CONDITION E	1.83	1.73
CONDITION F	1.65	1.55
CONDITION G	1.22	1.11

Close review of tables D-8 through D-14 indicates the various factors changed in developing the trip rate calculations. The variables considered were:

- Mode of Arrival/Departure Percentages
- Vehicle Occupancy Rates
- Peak Hour Arrival/Departure Rates
- Gross Square Feet Per Employee

TABLE D-8
CASE STUDY NO. 4
BASE CONDITION - A

* GROSS FLOOR AREA (SQ. FT.)		1027617	
* SQ. FT. / EMPLOYEE		265	
* TOTAL EMPLOYEES		3878	
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	6.5%	252	
Metrorail/Feeder Bus	1.0%	39	
Walk/Other	2.0%	78	
Vanpool	9.5%	368	
Auto	81.0%	3141	
	total	100.0%	3878
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		332	
Auto		2827	
	total	3158	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	11.00	332	30
Auto	1.25	2827	2262
	total		2292
* OVERALL OCCUPANCY RATE	1.38		
* AM PEAK HOUR	ARRIVAL RATE		VEH. TRIPS
Employee	55.00%		1260
Non-Employee	10.00%		106
(@ .28 trips/employee)			
Total Inbound Trips			1366
Total Outbound Trips			241
AM Peak Hour 2-way Trips			1608
* PM PEAK HOUR	DEPARTURE RATE		VEH. TRIPS
Employee	50.00%		1146
Non-Employee	12.00%		130
(@ .28 trips/employee)			
Total Outbound Trips			1276
Total Inbound Trips			225
PM Peak Hour 2-way Trips			1501
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour		1.56	
PM Peak Hour		1.46	

TABLE D-9
CASE STUDY NO. 4
CONDITION B:
CHANGE MODE-OF-ARRIVAL PERCENTAGES

* GROSS FLOOR AREA (SQ. FT.)	1027617		
* SQ. FT. / EMPLOYEE	265		
* TOTAL EMPLOYEES	3878		
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	4.0%	155	
Metrorail/Feeder Bus	2.0%	78	
Walk/Other	1.0%	39	
Vanpool	3.0%	116	
Auto	90.0%	3490	
total	100.0%	3878	
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		105	
Auto		3141	
total		3246	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	11.00	105	10
Auto	1.25	3141	2513
total			2522
* OVERALL OCCUPANCY RATE	1.29		
* AM PEAK HOUR	ARRIVAL RATE	VEH. TRIPS	
Employee	55.00%	1387	
Non-Employee	10.00%	106	
(@ .28 trips/employee)			
Total Inbound Trips		1493	
Total Outbound Trips		264	
AM Peak Hour 2-way Trips		1757	
* PM PEAK HOUR	DEPARTURE RATE	VEH. TRIPS	
Employee	50.00%	1261	
Non-Employee	12.00%	130	
(@ .28 trips/employee)			
Total Outbound Trips		1391	
Total Inbound Trips		246	
PM Peak Hour 2-way Trips		1637	
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour	1.71		
PM Peak Hour	1.59		

TABLE D-10
CASE STUDY NO. 4
CONDITION C:
CHANGE MODE-OF-ARRIVAL AND VANPOOL OCCUPANCY

* GROSS FLOOR AREA (SQ. FT.)	1027617		
* SQ. FT. / EMPLOYEE	265		
* TOTAL EMPLOYEES	3878		
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	9.0%	349	
Metrorail/Feeder Bus	5.0%	194	
Walk/Other	4.0%	155	
Vanpool	12.0%	465	
Auto	70.0%	2714	
total	100.0%	3878	
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		419	
Auto		2443	
total		2862	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	10.00	419	42
Auto	1.25	2443	1954
total			1996
* OVERALL OCCUPANCY RATE	1.43		
* AM PEAK HOUR	ARRIVAL RATE	VEH. TRIPS	
Employee	55.00%	1098	
Non-Employee	10.00%	106	
(@ .28 trips/employee)			
Total Inbound Trips		1204	
Total Outbound Trips		212	
AM Peak Hour 2-way Trips		1416	
* PM PEAK HOUR	DEPARTURE RATE	VEH. TRIPS	
Employee	50.00%	998	
Non-Employee	12.00%	130	
(@ .28 trips/employee)			
Total Outbound Trips		1128	
Total Inbound Trips		199	
PM Peak Hour 2-way Trips		1328	
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour	1.38		
PM Peak Hour	1.29		

TABLE D-11
CASE STUDY NO. 4
CONDITION D:
CHANGE VANPOOL AND AUTO OCCUPANCY

* GROSS FLOOR AREA (SQ. FT.)	1027617		
* SQ. FT. / EMPLOYEE	265		
* TOTAL EMPLOYEES	3878		
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	6.5%	252	
Metrorail/Feeder Bus	1.0%	39	
Walk/Other	2.0%	78	
Vanpool	9.5%	368	
Auto	81.0%	3141	
total	100.0%	3878	
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		332	
Auto		2827	
total		3158	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	10.00	332	33
Auto	1.10	2827	2570
total			2603
* OVERALL OCCUPANCY RATE	1.21		
* AM PEAK HOUR	ARRIVAL RATE	VEH. TRIPS	
Employee	55.00%	1432	
Non-Employee	10.00%	106	
(@ .28 trips/employee)			
Total Inbound Trips		1538	
Total Outbound Trips		271	
AM Peak Hour 2-way Trips		1809	
* PM PEAK HOUR	DEPARTURE RATE	VEH. TRIPS	
Employee	50.00%	1302	
Non-Employee	12.00%	130	
(@ .28 trips/employee)			
Total Outbound Trips		1432	
Total Inbound Trips		253	
PM Peak Hour 2-way Trips		1685	
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour	1.76		
PM Peak Hour	1.64		

TABLE D-12
CASE STUDY NO. 4
CONDITION E:
CHANGE VANPOOL OCCUPANCY AND ARRIVAL/DEPARTURE RATES

* GROSS FLOOR AREA (SQ. FT.)	1027617		
* SQ. FT. / EMPLOYEE	265		
* TOTAL EMPLOYEES	3878		
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	6.5%	252	
Metrorail/Feeder Bus	1.0%	39	
Walk/Other	2.0%	78	
Vanpool	9.5%	368	
Auto	81.0%	3141	
total	100.0%	3878	
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		332	
Auto		2827	
total		3158	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	10.00	332	33
Auto	1.25	2827	2262
total			2295
* OVERALL OCCUPANCY RATE	1.38		
* AM PEAK HOUR	ARRIVAL RATE	VEH. TRIPS	
Employee	65.00%	1492	
Non-Employee	10.00%	106	
(@ .28 trips/employee)			
Total Inbound Trips		1598	
Total Outbound Trips		282	
AM Peak Hour 2-way Trips		1879	
* PM PEAK HOUR	DEPARTURE RATE	VEH. TRIPS	
Employee	60.00%	1377	
Non-Employee	12.00%	130	
(@ .28 trips/employee)			
Total Outbound Trips		1507	
Total Inbound Trips		266	
PM Peak Hour 2-way Trips		1773	
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour	1.83		
PM Peak Hour	1.73		

TABLE D-13
CASE STUDY NO. 4
CONDITION F:
REDUCE SQUARE FEET/EMPLOYEE AND VANPOOL OCCUPANCY

* GROSS FLOOR AREA (SQ. FT.)	1027617		
* SQ. FT. / EMPLOYEE	250		
* TOTAL EMPLOYEES	4110		
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	6.5%	267	
Metrorail/Feeder Bus	1.0%	41	
Walk/Other	2.0%	82	
Vanpool	9.5%	390	
Auto	81.0%	3329	
total	100.0%	4110	
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		351	
Auto		2997	
total		3348	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	10.00	351	35
Auto	1.25	2997	2397
total			2432
* OVERALL OCCUPANCY RATE	1.38		
* AM PEAK HOUR	ARRIVAL RATE	VEH. TRIPS	
Employee	55.00%	1338	
Non-Employee	10.00%	106	
(@ .28 trips/employee)			
Total Inbound Trips		1444	
Total Outbound Trips		255	
AM Peak Hour 2-way Trips		1699	
* PM PEAK HOUR	DEPARTURE RATE	VEH. TRIPS	
Employee	50.00%	1216	
Non-Employee	12.00%	138	
(@ .28 trips/employee)			
Total Outbound Trips		1354	
Total Inbound Trips		239	
PM Peak Hour 2-way Trips		1593	
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour	1.65		
PM Peak Hour	1.55		

TABLE D-14
CASE STUDY NO. 4
CONDITION G:

INCREASE SQUARE FEET/EMPLOYEE ; REDUCE VANPOOL OCCUPANCY

* GROSS FLOOR AREA (SQ. FT.)	1027617		
* SQ. FT. / EMPLOYEE	350		
* TOTAL EMPLOYEES	2936		
* MODE OF ARRIVAL	PERCENT	PERSONS	
Bus	6.5%	191	
Metrorail/Feeder Bus	1.0%	29	
Walk/Other	2.0%	59	
Vanpool	9.5%	279	
Auto	81.0%	2378	
total	100.0%	2936	
* AVERAGE DAY EMPLOYEES (10% absentees)			
Vanpool		251	
Auto		2140	
total		2391	
* VEHICLE TRIP ESTIMATES	OCCUPANCY	PERSONS	VEHICLES
Vanpool	10.00	251	25
Auto	1.25	2140	1712
total			1737
* OVERALL OCCUPANCY RATE	1.38		
* AM PEAK HOUR	ARRIVAL RATE	VEH.	TRIPS
Employee	55.00%		956
Non-Employee	10.00%		106
(@ .28 trips/employee)			
Total Inbound Trips			1062
Total Outbound Trips			187
AM Peak Hour 2-way Trips			1249
* PM PEAK HOUR	DEPARTURE RATE	VEH.	TRIPS
Employee	50.00%		869
Non-Employee	12.00%		99
(@ .28 trips/employee)			
Total Outbound Trips			967
Total Inbound Trips			171
PM Peak Hour 2-way Trips			1138
* TRIP RATE / 1000 SQ. FT. (2-WAY)			
AM Peak Hour	1.22		
PM Peak Hour	1.11		

The objective was to illustrate the impact of listed "default" values in the office trip generation rate technique in a typical site access study. Condition A represents the base condition. Conditions B and C evaluate changes in the percentage of employee arrival/departure by mode to the office complex. Condition B increases the automobile mode of arrival by 9% while Condition C deals with a 11% reduction to 70% arrival by auto as compared to Condition A. Adjustments were made to the bus, metrorail, and walking modes percentages. Vanpool arrival percentages were controlled so that overall vehicular occupancy rates fluctuated inversely with the automobile arrival percentages. Condition D lowered the vehicle occupancy rate for automobiles from 1.25 (Condition A) persons per vehicle to 1.1 persons per vehicle. This lowers the overall vehicle occupancy rate from 1.38 to 1.21.

Condition E adjusted the peak hour arrival/departure rates to the suggested default values, in this case, increasing the percent of employee trips during the peak hour by 10% from Condition A. Conditions F and G adjusted the assumption of the employee density for office building types. For the base Condition A, a 265 square foot per employee was used. The default values of 250 and 350 were substituted along with the other Condition A assumptions and the appropriate levels of service were determined.

LOS Sensitivity Results

A review of Table D-15 indicates that for Conditions A through F while the office trip generation rates vary significantly between 1.38 and 1.83 (AM) and 1.29 and 1.73 (PM) there is not much variation in the levels of service at any one of the four intersections. Location 1 experiences LOS E's intermittently but there is very little difference between the LOS D's and LOS E's in most instances. These trip rates reflected a variation in the mode of arrival/departure, vehicle occupancy and peak hour arrival/departure. Condition G however, reflects the lowest office trip generation rates, 1.22 and 1.11, and this condition indicated significantly improved level of service values at all intersections. These rates reflect an increase in the number of square feet per employee, or a reduction in the number of employees in the office buildings.

TABLE D-15
CASE STUDY NO. 4
PEAK HOUR LEVEL-OF-SERVICE COMPARISON:
CONDITIONS A THROUGH G

CONDITION		Intersection							
		1		2		3		4	
		LOS	/ VOL	LOS	/ VOL	LOS	/ VOL	LOS	/ VOL
"A"	AM	D	1239	A	828	B	869	D	1141
	PM	D	1268	C	1011	D	1170	D	1124
"B"	AM	E	1282	B	883	B	897	D	1171
	PM	E	1290	C	1049	D	1192	D	1131
"C"	AM	D	1215	A	791	B	869	D	1121
	PM	D	1246	B	967	D	1141	D	1116
"D"	AM	E	1293	B	897	B	900	D	1178
	PM	E	1296	C	1061	D	1200	D	1134
"E"	AM	E	1307	B	915	B	907	D	1188
	PM	E	1314	C	1096	D	1223	D	1141
"F"	AM	D	1271	B	868	B	892	D	1162
	PM	E	1289	C	1047	D	1191	D	1131
"G"	AM	D	1179	A	747	B	856	C	1096
	PM	D	1232	B	940	C	1123	C	1110
		(PHASING)							
		3 PHASE		3 PHASE		3 PHASE		3 PHASE	

LEVEL OF SERVICE CRITERIA
(Vehicles/Hour)
3 PHASE

LOS	
A	0 - 855
B	855 -1000
C	1000 -1140
D	1140 -1275
E	1275 -1425
F	1425 -ABOVE

SUMMARY

At location 1, the key intersection studied, the following changes resulted in less efficient peak hour levels of service, by changing LOS D to LOS E:

- Condition B: increasing the mode of (auto) arrival from 81% to 90% or reduction in other modes of travel.
- Condition D: reducing the auto vehicle occupancy rate from 1.25 to 1.1 (reduction in ridesharing)
- Condition E: increasing the arrival/departure rates from 55/50 to 65/60 (reduction in staggered work hours)